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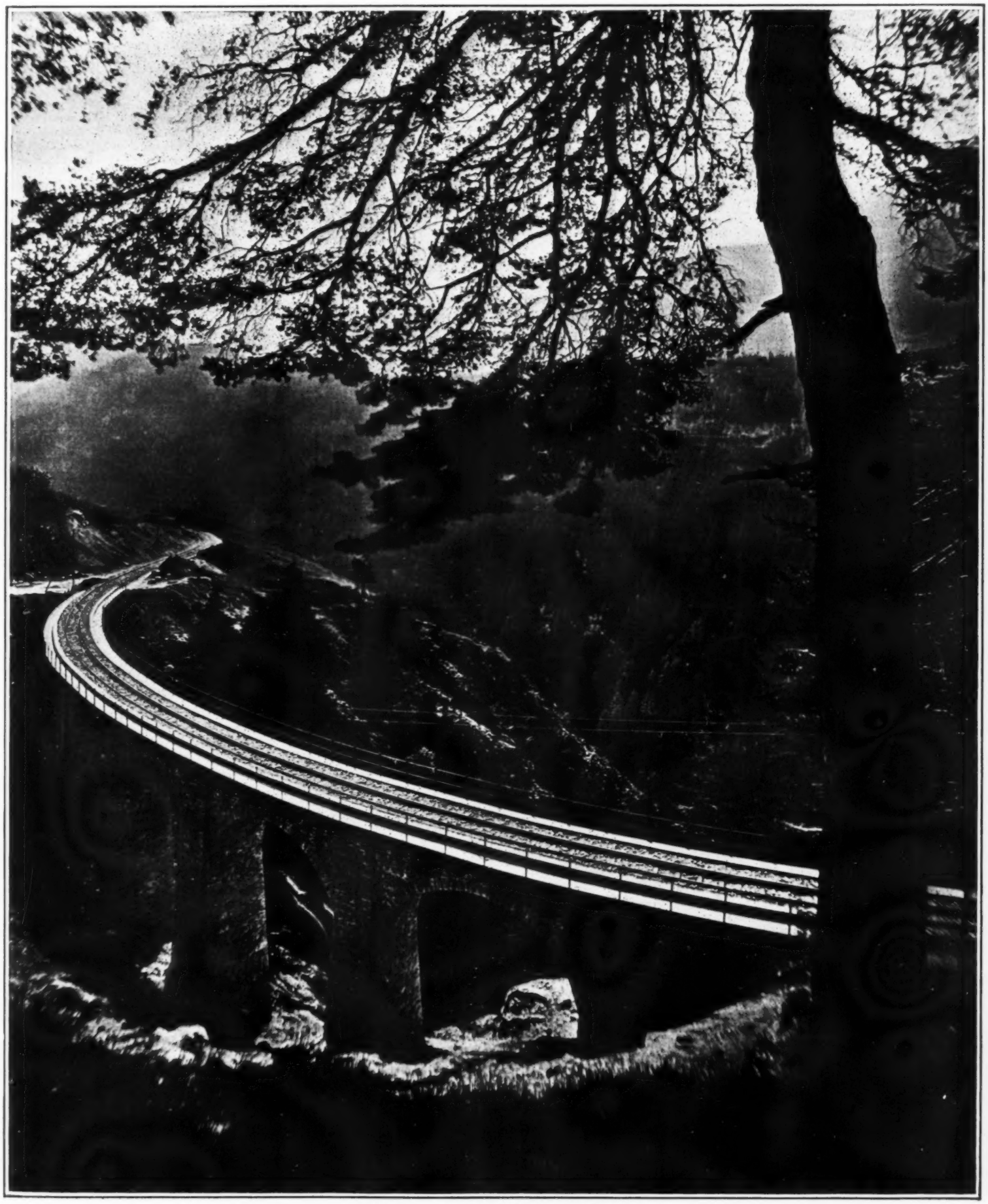

A picturesque view of the line in the high Alps.

THE NEW FURKA PASS RAILWAY IN SWITZERLAND.—[See page 344.]

Developments in Electromagnetism—I*

A Review of Some Important Problems, and the Laboratory Results

By Eugene Bloch, Professor at the Lycée Saint Louis

THE domain of electromagnetism is to-day so broad and so complex that in a few pages we cannot hope to show all its frontiers. For the present, therefore, we will limit ourselves to reviewing certain problems which particularly attract our attention, either by the number or the importance of the investigations which they have produced. We will start with the theoretical developments and end with the results gained in the laboratory.[1]

I. THE DYNAMICS OF THE ELECTRON AND ELECTROMAGNETIC MASS.

The electromagnetic theory of matter and the ether in the perfected form due to H. A. Lorentz is really a theory of electrons. Matter in all its forms is by it considered as made up of complex groups of which an essential element is the negative electron either free or bound to an atom. This element is defined by its charge e (4.5×10^{-10} electrostatic units) and its mass, which is invariably at small velocities ($e/m = 1.76 \times 10^7$ electromagnetic units). This result was the logical consequence of a long and brilliant series of discoveries which marked the end of the last and the beginning of the present century (cathode rays, X-rays, gaseous ions, Zeeman effect, radioactivity, etc.).

A fundamental problem of this theory is evidently the study of the motion of an isolated electron and the electromagnetic perturbations which accompany it. This problem gains in interest as experimental demonstration becomes possible. Cathode rays from all sources (rays from Crookes's tubes, from the photoelectric effect, the β rays from radium) are, indeed, fluxes of electrons projected at great velocities from matter. Let us, therefore, review first the important results of the theory which was developed by Heaviside and Searle and later and fundamentally by J. J. Thomson (1881), a theory which has passed through many successive developments.[2]

(1) An electron moving with a uniform velocity, or at least a velocity only slowly variable (quasi-stationary), carries invariably tied to it an electromagnetic field the form of which can be completely deduced from the Maxwell-Lorentz equations. This moving field has been called the "velocity wave."

(2) If the electron suffers an acceleration, a wave is immediately propagated from it having all the characteristics of a luminous wave (transverse vibrations, rectangular electric and magnetic fields). This disturbance has been called an "acceleration wave." At great distances from the electron the latter wave alone exists because its amplitude varies inversely as the distance from the electron and not as the inverse square as does that of the other wave. This shows us the probable origin of luminous radiations and the root of the explanation of the Zeeman effect. Here also we find the explanation of X-rays which are electromagnetic pulses[3] due to the abrupt stoppage of cathode corpuscles at the anticathode and the resulting negative acceleration.

(3) In order to give an electron a quasi-stationary movement there must be communicated to it energy which is stored up in its field as electric and magnetic energy. The necessary calculations for this field are relatively simple where the ratio (β) of the velocity (v) of the particle to the velocity of light (V) is small. They become more complicated where β approaches unita and were first made completely by Max. Abraham[4] in 1903 upon the hypothesis of a rigid, spherical electron carrying a charge uniformly distributed throughout its volume. Then the magnetic energy of the field can always be expressed in the form of kinetic energy, $\frac{mv^2}{2}$. It is quite natural to speak of the coefficient m as the electromagnetic mass of the electrons. This mass may be superposed upon the ordinary mass, at least it does not wholly take its place. This leads to an electromagnetic interpretation of mechanics. In this new mechanics, the mass m does not maintain a constant value m_0 except at very small velocities. For a velocity comparable with that of light (β near 1) the mass becomes a function of β and increases indefinitely as β approaches unity. Further, it is necessary to distinguish between a longitudinal and a transverse mass according to the orientation of the acceleration with regard to the velocity. The transverse mass, detectable only in the experiments with the deviations of the cathode rays, is given according to Max Abraham by the relation

$$\frac{m}{m_0} = \frac{3}{4\beta^2}\left\{\frac{1+\beta^2}{2\beta} L \frac{1+\beta}{1-\beta} - 1\right\}$$

This formula seemed completely verified by the observations of Kaufmann[5] (1900 and 1903). He measured the variation of the ratio e/m with the velocity for the β rays from radium, utilizing the electric and magnetic deviations of the electrons having velocities reaching ninety-five one-hundredths of the velocity of light.

Since then other formulæ have been proposed in the place of this. Langevin and Bucherer,[6] basing their formula upon the hypothesis of a deformable electron of constant volume, obtained

$$\frac{m}{m_0} = (1-\beta^2)^{-\frac{1}{3}}$$

Further, as a consequence of the development of the theory of relativity (see Section II of this article), H. A. Lorentz, postulating an electron of constant equatorial diameter, deduced a third formula:

$$\frac{m}{m_0} = (1-\beta^2)^{-\frac{1}{2}}$$

These new formulæ also appear to fit the experiments of Kaufmann. It became necessary, therefore, to make new experiments more precise than those of Kaufmann in order to choose between the various formulæ. Several attempts to do this have been made.

Bucherer[7] placed a grain of radium fluoride at the center of a condenser formed of two flat disks 8 centimeters in diameter and separated by 0.25 millimeter. This condenser was inclosed in an air-tight cylindrical box, the walls of which carried a photographic film. This was all placed in a uniform magnetic field parallel to the plates and a very perfect vacuum produced. When the condenser is charged, the β rays trace upon the film a line the analysis of which permits the calculation of the variation of e/m with the velocity. In this case the formula of Lorentz is found to fit best, confirming nicely the principle of relativity.

These conclusions have been clenched by yet later experiments. Hupka[8] used the electrons from the photoelectric effect, produced in a very perfect vacuum and accelerated by intense electric fields reaching a strength of 90,000 volts. The knowledge of the velocity v and the ratio e/m was deduced from the magnetic deviation, rendered evident by a fluorescent screen, and the magnitude of the accelerating potential. The maximum velocities obtained were of the order of $v/2$. The formula of Lorentz fits these observations also better than that of Abraham. However, these experiments are less convincing than the preceding one, as Heil noted,[9] since the highest potentials must be known with a precision greater than 1 per cent, an accuracy difficult to obtain.

C. E. Guye and Ratnovsky,[10] desirous of escaping this difficulty, used ordinary cathode rays, produced in a good vacuum, and deviated at the same time both electrically and magnetically so as to get rid of the necessity of measuring the potential used. These results also confirm Lorentz's formula at the expense of Abraham's.

We are led by all these results to look upon an electron as deformable only in the direction of its motion, conformable with the principle of relativity; in this respect they undergo the contraction of Lorentz (see further on). Do all difficulties now disappear? Without considering the objections of a more general nature which are to-day urged against the principle of relativity (see Section II), we must say, no. As H. Poincaré[11] has observed, we cannot comprehend why an electron does not disintegrate spontaneously under the influence of the electric and magnetic forces due to its charge unless there comes into play, in order to maintain equilibrium, other forces from without analogous to pressure. We are led thus to introduce something further than pure electromagnetism as a basis of our new mechanics. We are just as far as ever from comprehending the primordial forces underlying matter.

II. THE PRINCIPLE OF RELATIVITY.

Lorentz has shown that the electromagnetic theory furnishes an explanation of the negative results of the experiments which were expected to demonstrate, either by electrical or optical means, the movement of translation of the earth relative to the supposed stationary ether. These experiments could detect only the effects of the first order with reference to β (quotient of the velocity of translation of the earth, v, relative to the velocity of light, V), while theory shows that the effects should be of the order of β^2 or smaller. This theory then received a rude shock from the celebrated experiment of Michelson (1881) relative to the interference of two rays propagated at right angles to each other and which should show the terms of the second order of β. The negative result was irreconcilable with the theory, the effect observed being less than one one-hundredth of that calculated.[12] We must therefore modify the theory.

The modification necessary was announced almost at the same time by Lorentz and by Fitzgerald. It consisted in supposing that a moving solid body suffers a contraction in the direction of its motion equal to $\beta^2/2$. This is the celebrated hypothesis known as the "contraction of Lorentz." It seems very strange at first sight and instigated the experiments by Lord Rayleigh,[13] and by Brace,[14] who tried to find evidence of this contraction in the double refraction which it should produce. Their results were negative. In order to explain these consequences and place the theory in a more satisfactory form, Lorentz was led to a hypothesis which contained the germ of the theory of relativity.[15] He showed that the electromagnetic equations for bodies in motion could be put in the same form as for bodies at rest by means of what is called the "transformation of Lorentz." This permits the expression of the co-ordinates x, y, z, and the time t for a system in motion as a function of the co-ordinates x_0, y_0, z_0, and t_0 for the system at rest, thus establishing a correspondence between the electric and magnetic fields of the two systems. This group of transformations contains, as a particular case, the hypothesis of contraction, which is found to be of the magnitude $(1-\beta^2)^{1/2}$, in agreement almost to terms of the fourth order with the magnitude originally admitted. It further explains the negative results of Michelson, Rayleigh, and Brace. Through it we understand the negative results of Trouton and Noble in their electrostatic experiment which was expected to indicate the terms of β^2.[16]

The experiments explained by the transformation of Lorentz go only to the terms in β^2. We do not know any at present which go farther, but it is natural to suppose that even taking into account terms of higher orders, we will never be able to get evidence of the motion of translation of the earth with reference to the ether. In other words, we can probably detect only the relative motions of two material systems with reference to each other and not their absolute movement with reference to a supposed stationary ether. This novel hypothesis was announced in its most general form for the first time by Einstein,[17] who named it the principle of relativity. Starting with this simple principle, Einstein modified slightly the transformation of Lorentz, giving to it a physical basis of very great generality and gathering all the conclusions resulting from it into a group of perfectly consistent formulæ.

We will not state here all the physical and philosophical consequences of this theory of relativity. We will note only the absolute character assumed by the two fundamental postulates of this theory: First, the ether is immovable and penetrates matter perfectly; second, the velocity of light is an absolute invariant and rep-

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* Translated from *Revue générale des Sciences pures et appliquées*, Paris, 24th year, No. 8, April 30th, 1913, in the Annual Report of the Smithsonian Institution for 1913.

[1] It will be out of the question, for instance, in this review to consider the recent researches on the larger ions, X-rays, radioactivity, vacuum tubes, and the phenomena connected with them (positive rays, etc.), or atmospheric electricity.

[2] See the references cited further on.

[3] We have not sufficient space to describe the curious theory of Bragg, according to which the X-rays and the τ rays of radium are uncharged particles of matter. Moreover, this theory appears to be contradicted by the recent beautiful experiments of Lane and his pupils upon the diffraction of X-rays by crystals. (Bragg, *Phil. Mag.*, October, 1907; *Chem. News*, vol. 97, p. 162, 1908; *Radium*, p. 213, 1908. See also articles by Brunet in this *Revue* for February 15th, 1913.)

[4] See *Ions, electrons and corpuscles*, vol. 1.

[5] See *Ions, electrons and corpuscles*, vol. 1.

[6] Langevin, *Revue générale des Sciences*, p. 267, 1905.

[7] Bucherer, *Physik. Zeitschrift*, vol. 9, p. 755, 1908; *Annalen der Physik*, vol. 28, p. 513, 1909.

[8] Hupka, *Verh. der Deutsch. Phys. Gesellsch.*, vol. 11, p. 249, 1909; *Annalen der Physik*, 1910.

[9] Heil, *Annalen der Physik*, vol. 31, p. 519, 1910.

[10] Guye and Ratnovsky, *Comptes Rendus*, CL, p. 326, 1910.

[11] H. Poincaré, *Rendiconti del Circolo Math. di Palermo*, vol. 21, p. 129, 1906.

[12] The original experiment was made by Michelson and Morley in 1887 and repeated most recently by Morley and Miller, *Phil. Mag.*, vol. 9, p. 680, 1905.

[13] Rayleigh, *Phil. Mag.*, vol. 4, p. 678, 1902.

[14] Brace, *Phil. Mag.*, vol. 7, p. 317, 1904.

[15] See the admirable book by Lorentz, entitled "The Theory of Electrons," and published by Teubner in Leipzig, 1909.

[16] Trouton and Noble, *Phil. Trans.*, vol. 202, p. 165, 1903. See also Langevin, *Comptes Rendus*, vol. 140, p. 1171, 1905.

[17] Einstein, *Annalen der Physik*, vol. 17, p. 902, 1906.

resents a superior limit which no other velocity can exceed (whether for matter in motion or the propagation of waves). The theory has been further developed (principally by Germans) by Einstein (1905-1912), Minkowski (1905-1908), Planck (1907-1908), Born (1909), Sommerfeld (1910), Laue (1911), etc. The various points of view which these physicists have adopted are too numerous to be given here in detail; some have tried to put the transformations of Lorentz into more geometrical and comprehensive form (Minkowski); others have deduced the kinetic consequences of the principle, either for a moving point (composition of velocities according to Sommerfeld) or for a solid body in rotation (Born, Laue, etc.). Difficulties and complications quickly arise as soon as the motion of uniform translation originally supposed is departed from and these difficulties have not yet been overcome. The total absence of any experimental basis or confirmation of these later developments deters us from further discussion. We will stop a moment only on one of the most paradoxical consequences of the principle of relativity which will bring out the difficulties which the theory encounters and rebut the absolutism of the principles which it uses as bases of the physical sciences. At the start Einstein[18] showed that if the energy of a system increases by the amount E, *the principle of relativity requires that its mass increases at the same time by* E/V^2. Only on this condition can the principle of the conservation of the movement of the center of gravity as well as the new system of mechanics be maintained. Accordingly, mass and energy are not really distinct; the principle of the conservation of mass is inseparable from the principle of conservation of energy. This result, however strange, is nevertheless consistent in itself.

Einstein himself, basing his deductions on this consequence, tried to bring back to the principle of relativity the absolute value which had been attributed to it since 1905.[19] He has tried to include in the electromagnetic synthesis of the universe the phenomenon of gravity, hitherto so rebellious against all our efforts at explanation. He noted that a uniform gravitational field of constant acceleration, γ, is equivalent to a medium free from gravitation in which the reference axes are supposed acting with a uniform acceleration $-\gamma$. Next we must generalize the principle of relativity and pass from the case considered until now of a uniform velocity of translation to that of a uniform acceleration. In the earlier case we were led to attribute to energy a mass $m = E/V^2$; now, if we wish to preserve the principle in its entirety we must attribute to the same energy the weight $m\gamma$. As a particular case, radiant energy, light, must have weight; a beam of light must then be deviated by the masses close to which it may pass. Einstein's calculation showed, for example, that the angular distance between a star and the center of the sun must be decreased by about one second when the star appears close to the sun. The measurement could be attempted at a total eclipse of the sun.

There is no need of calling attention to the strangeness of these conclusions. The important thing from a philosophical point of view is that we are obliged to give up the absolute invariability of the velocity of light, V, considered at the start as an unassailable axiom. This invariability is only true in a system where the gravitational potential δ remains constant. For variable potentials the velocity of light must vary according to the formula, $V = V_0 (1 + \delta/V^2)$. So it is only in the case of uniform motion of translation that the transformation of Lorentz represents the phenomena of a system in movement. In the more general case the group of transformations is more complicated and as yet undetermined; the equations to be substituted for those of the classic electromagnetism are also undetermined.

This new point of view of Einstein has at least one incontestable utility: It makes us realize that the postulates which were at the basis of the earlier principle of relativity (the invariability of V, etc.) are perhaps only approximate affirmations, susceptible of modification, and not first truths. It has led us from metaphysics to physics. And since the discussion became opened anew concerning the foundations proposed by Einstein we will not be surprised to find that Max Abraham, adopting this new conception of mass and weight, has developed a new theory of gravitation, different in many respects from that of Einstein. Abraham[20] renounces the generalization of the principle of relativity in the case of acceleration. Then considering that as a whole the principle of relativity has failed, he keeps the Lorentz transformation only for very small changes in the variables. Considerable discussion has passed between him and Einstein, but we will not follow the details.[21]

Admitting that these theories will have a lasting effect upon science, in the future new experiments will be required and a more powerful theoretical effort than that of the past. We will close our exposition of this question by citing the opinions of several skeptical physicists who, from the beginning, have found the postulates upon which the theory of relativity rests too absolute and to whose voices we are now beginning to listen.

The ether in the principle of relativity has been emptied little by little of all its physical properties; it is represented now only by a system of mathematical equations, those of Maxwell-Lorentz, and a number, the velocity of light. It remains as the vehicle of radiant energy without our questioning how. Ritz,[22] following to the logical conclusions such notions, proposes to renounce wholly the hypothesis of an ether and to return to a theory very close to the old one of emission. According to him, we need not speak of electric and magnetic fields, but only of electric charges acting upon each other. We thus return to action at a distance but taking into account the finite velocity with which such action takes place. Consequently, it is necessary to throw away the partial differential equations of the electric field and replace them with integrals (retarded potentials). There is thus introduced an irreversibility of which the former equations could not take account. Mass at great velocities will remain constant, but the force will vary. We thus arrive at another system of mechanics. Against these new conceptions, the development of which was unfortunately interrupted by the death of the author, there are grave objections which have so far kept the majority of theorists from adopting them, although they are perfectly consistent among themselves.

Brillouin,[23] on the other hand, makes the ether more substantial than has been customary. There must be, according to him, a drastic revision of the hypotheses relative to it. For example, its absolute immobility, perfect permeability, homogenity, isotropy, and the invariability of the velocity of light. Those upholding the principle of relativity have themselves commenced to attack the last postulate, as we have just seen. Now it will be the turn of the other properties. We may come, through the increasing acuteness of our powers of analysis, to admit, to a closer degree of approximation, that the ether, at least slightly, is similar to ordinary matter, that it may propagate a disturbance with a velocity greater than that of light, that it does not remain perfectly stationary when matter traverses it, etc. New experiments must be added to the purely electro-optic ones of Michelson, Rayleigh, Brace, and Troughton before we will be able to build these theories.

(To be continued.)

[18] Einstein, l. c. and *Annalen der Physik*, vol. 20, p. 627, 1906; vol. 23, p. 378, 1907, etc.

[19] Einstein, *Jahrbuch der Rad. and Electronik*, vol. 4, p. 4; *Annalen der Physik*, vol. 35, p. 898, 1911, etc.

[20] Max Abraham, *Phys. Zeitschr.*, vol. 13, No. 1, 1912; *Annalen der Physik*, vol. 38, p. 1,056, vol. 39, p. 444, 1912; *Nuovo Cimento*, January, 1913.

[21] Einstein, *Annalen der Physik*, vol. 38, pp. 355 and 1,059, 1912; vol. 39, p. 704, 1912.

[22] Ritz, *Annales de chimie et de physique*, vol. 13, p. 145, 1908.

[23] Brillouin, *Scientia*, vol. 13, p. 10, 1913. See the *Revue générale des Sciences*, March 30th, 1913, p. 214.

Phenol for Coal Analysis

BROADLY speaking, coal is analysed and tested for practical purposes in two ways. In one case the elementary constitutents of the coal—carbon, hydrogen, oxygen, and nitrogen—are determined separately by ultimate analysis, in addition to moisture and ash; the data obtained are useful for calculating the total heat content or calorific value of the coal. Alternatively the volatile matter is separated by distillation from the fixed carbon; the ratio of the two, designated the fuel ratio, in a certain measure indicates how much of the coal will be available as coke and how much in volatile and condensable products. Neither of the two methods gives any clue as to the real constituents of the coal, which is more or less a complex of hydro-carbons. But as it is quite understood that coal changes in the course of time, and that the period during which a coal may be stored without serious loss, its spontaneous combustion, smoke formation, and the behavior of coal in general depends upon the nature of the original constituents, other methods have been tried. These latter methods are still in the research stage. The general idea of the research is to separate the different constituents so far as possible by the use of solvents. Already at the time of the first London Exhibition of 1851, Smythe tried benzine, chloroform, alcohol, acetone, ethyl ether, and petroleum ether, for this purpose on a lignite from the Rhine; Remsch, in 1885, used alkaline solvents. H. B. Baker, in 1901, and A. Wahl, and several others after him applied pyridin with better results than previously obtained. A. H. Clark and R. V. Wheeler[1] found that pyridin roughly separated the coal into an extract containing mainly the resinous substances—i. e., the degradation products of the resins and gums in the plants which had been transformed into coal, and an insoluble residue consisting of the degradation products of the cellulose; by further treating the pyridin extract with chloroform they obtained an extract almost entirely resinous in character. They also observed that the destructive distillation of coal gave, below 750 deg. Cent., chiefly "paraffin-yielding" constituents derived from the resinous compounds, and above that temperature "hydrogen-yielding" compounds (mainly hydrogen and oxides of carbon). Thus the extraction with pyridin and chloroform effected somewhat the same separation of the coal constituents as the destructive distillation, and coal would appear to consist of two types of constituents, differing as to the case of their decomposition.

Other organic solvents were tried in 1912 by Frazer and Hoffman (Technical Paper 5 of the United States Bureau of Mines). They found phenol to be a suitable solvent, and phenol in particular has been experimented with by S. W. Parr and H. F. Hadley in the Engineering Experiment Station of the University of Illinois (see Bulletin 76 of that station). Parr and Hadley have studied a great many organic solvents as to their effectiveness as solvents for coal. In the first rank they put phenol [$C_6 H_5 O H$, chemically the alcohol of benzine; it has the character of an acid, and is commonly styled carbolic acid]. The several cresols, aniline and methyl aniline, otherwise efficient, decomposed during the extraction. Pyridin came next in order, but it appeared to introduce some nitrogen into the extract, a fact already noticed by others; acetone, benzine, carbon disulphide, and turpentine gave only small amounts of extract. When the extraction in the hot by means of phenol was continued too long, above 20 hours, a little phenol or some decomposition product of it remained.

Fifteen different coals, mostly from various mines in the State of Illinois, have been treated with phenol, generally in samples of about 5 grammes, ranging in ash content from 3 to 13.5 per cent. In all cases the extract and the residue together approximately made up 100 per cent, again showing that the continued extraction did not lead to any loss or gain of substance. The proportions of extract to residue varied greatly in different cases, a lignite from Wyoming yielding only 0.6 gramme of extract, a Pocahontas coal from Western Virginia only 0.09 gramme; the average weight of extract was about 1.5 gramme, the rest being insoluble residue. The extract had in most cases a sufficiently definite melting-point and decomposition temperature, and seemed to be the vital constituent concerned in the coking. Both the extract and the residue, especially the latter, as well as the coal itself, readily absorbed oxygen, and the oxygen seemed to be chemically bound. In this respect Parr and Hadley differ from Clark and Wheeler, who assumed that the oxygen formed more or less loose additional complexes, not of definite compositions, with the constituents of the coal. The coking property of the extract was decidedly impaired by the absorption of oxygen.

These are the chief results. We will give a few particulars of the experiments, which appear to have been conducted with care and forethought. Owing to the importance of avoiding oxidation, the continuous extraction, at 110 deg. Cent., was generally effected in an atmosphere of carbon dioxide. At higher temperatures, more extract and less residue was obtained than at 110 deg. Cent. In order to free the product from the solvent, phenol, distillation was carried on at reduced pressure. The cooled extract softened when heated above 300 degrees, without at first becoming sticky; at higher temperature it swelled to three or four times its volume, gave off volatile matter, and left a very friable, shiny mass; not heated above 350 degrees, it became brittle again on cooling. The heated residue also yielded volatile matter, and a very poor, non-caking kind of coke. When the extract and the residue were mixed again in the original proportions, a proper coke could be obtained. A great many coking (destructive distillation) experiments were made, and the photographs of the products are interesting. Both the residue and the extract were hygroscopic, the residue particularly. The ultimate analyses of the original coal, the extract, and the residue differed little as to the proportions of the main elements, while the pyridin extracts seem to be less rich in oxygen than the coal itself. Slow or rapid oxidation, at ordinary or higher temperature, decreased the solubility of the coal in phenol; the residue could be exposed to 105 deg. Cent. without altering it noticeably, because the coking property depends mainly on the extract. The destructive distillation of the three substances—coal, extract, residue—gave less ethylene and ethane and similar compounds, but more carbon dioxide and carbon monoxide when the materials had previously been oxidized than when not. This is the reason why Parr and Hadley assume that the oxygen enters into chemical combination with both residue and extract, and is not merely absorbed or adsorbed.

[1] Transactions of the Chemical Society, 1913, pages 1704; *Engineering*, vol. xcvi., pages 488.

European Aeronautical Laboratories—II*

Their Organization, Equipment, and Method of Investigation

By A. F. Zahm, Ph.D.

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2055, Page 330, May 22, 1915

FRENCH AERONAUTICAL LABORATORIES.

The Laboratoire Aerodynamique Eiffel consists of a single building with offices, a wind tunnel and various appurtenances, there being no workshops in the establishment. The wind-tunnel room measures, in round numbers, 40 by 100 feet, by 30 feet high; the three office rooms and garden cover about half as much additional space. Two wind-tunnels, a large and a small one, placed side by side, occupy the center of the room. They are placed well above the floor, to admit of a more nearly symmetrical flow of air. Considerable furniture—shelves, drawers, etc.—are placed about the walls; but the body of the room is kept somewhat free of obstructions to secure a less disturbed circulation.

Each tunnel comprises three main parts: the short bell-mouth intake, the model chamber, the long bell-mouth exit. The air from the room traverses the intake through honey-combs placed at either end of the bell-like form; then passes at its maximum speed in uniform rectilinear current across the model chamber; then flows in gently expanding stream and with diminishing speed onward to the larger end of the exit, where it encounters the fan which drives it with replenished energy into the open room. The model chamber is thus seen to be an enlargement of the tunnel proper, spacious enough to accommodate observers, and so sealed from the surrounding room as to have the same barometric pressure as the inflowing current at its narrowest section.

This type of tunnel, adopted by Eiffel after mature experience, has been patented by him as having features of considerable value. He prizes particularly the vacuum chamber for the observers, and for the freer flow of air about the models, uninfluenced by constraining walls. He also prizes the expanding exit, or "diffusor," for slowing the air as it approaches the fan and exhausts into the room, thus realizing great economy of power in maintaining the circulation. It is doubtful, however, whether any of the main features of Eiffel's tunnel are patentable in America. The bell-mouth entrance and exit have been known here many years. The vacuum chamber was employed by Mr. Mattullath and myself in our wind-tunnel constructed in 1901; was disclosed to many others then; and shortly thereafter was described in public prints.

The true function of the "diffusor," or expanding exit, seems to be to prevent turbulence, and thus to promote economy of flow, rather than to increase the pressure of the stream before it reaches the fan, as taught by Eiffel. In other words, the economy of circulation can be achieved by placing the screw at a narrower part of the exit cone, if the pitch of the blades be properly adapted to the stream at that section. But Eiffel's present arrangement presents structural advantages.

The circulation in the large tunnel is maintained by a Rateau screw suction ventilator with helicoidal blades. The screw is driven by a 50-horse-power electric motor, which is found sufficient to maintain a constant flow at any desired speed up to 32 meters per second, or say up to 70 miles per hour. This is a notable result, since the air stream at its swiftest section measures two meters in diameter.

* Smithsonian Miscellaneous Collections. vol. 62, No. 3.

The air velocity in Eiffel's tunnel seems to be satisfactory while used for engineering studies rather than for exact researches in physics. The velocity at all points of a cross-section is uniform in magnitude to within two per cent, and varies but little in direction. A fine silk thread, however, moored in the current, plays a trifle to and fro in both the horizontal and the vertical direction. The current velocity also fluctuates in time, say 1 to 2 per cent.

This velocity is determined, as in the English and other laboratories, from the pressure difference between the vacuum chamber and the large room enclosing the tunnel. This pressure difference is measured with a Shultze manometer, or inclined tube containing alcohol and provided with a graduated scale. In ordinary practice the end of the alcohol column plays several per cent above and below a mean reading, but can easily be located on the scale to within 4 per cent by a capable observer. This means that the velocity can be determined truly to within 2 per cent.

For convenience, in the determination of the wind effect on the various kinds of models, Eiffel places his measuring instruments on a platform, or bridge, spanning the vacuum room, and supported on either side by wheels resting on iron rails secured to the walls, so as to be moved aside when desired. Sometimes also the models are supported on a frame which can be wheeled along the floor. Thus apparatus can be adjusted outside the tunnel, quickly run into place, and again removed without dismantling. This is a unique advantage of Eiffel's arrangement. The main apparatus so employed are the aerodynamic balances, the propeller tester, and the instruments respectively for finding the distribution of pressure and the magnitude and line of action of the total wind force.

Of the *two balances* the simple bell-crank one for the precise measurement of smaller forces has been sufficiently explained as to principle in describing the English laboratory. The large aerodynamic balance, invented by Eiffel himself for determining the lift and drift of the whole wind force, and its line of action, is elaborate in theory, structure, and pratical operation, and is well explained in Eiffel's book, "The Resistance of the Air and Aviation." It is not sensitive enough for measuring the smaller forces on inclined planes and on small models.

The propeller tester is elegantly simple in design and operation. A vertical electric motor, mounted on the bridge above the tunnel, and having its shaft extended down through a wind shield to the center of the air stream, there engages, through bevel gearing, with the horizontal shaft of the model propeller. The shafting of the armature and the propeller are encased in a sheathing which also contains the bearings, and transmits the propeller thrust and torque to the base of the motor. The motor, in turn, is so mounted on pivots and hydraulic gauges as to measure the thrust and torque without material displacement. At the same time the motor speed is indicated by a tachometer attached to the upper end of the armature shaft. The wattmeter method, however, has lately replaced the direct method of measuring propeller torque.

The apparatus for measuring the distribution of air pressure over the surface of models has long been used by others, and in principle is like that employed in the English laboratory, and hitherto described in this report. The instrument for finding directly the line of the resultant air force, or "center of pressure," on a model surface is also an old contrivance, and need not be explained here. It is fully described in Eiffel's book.[4]

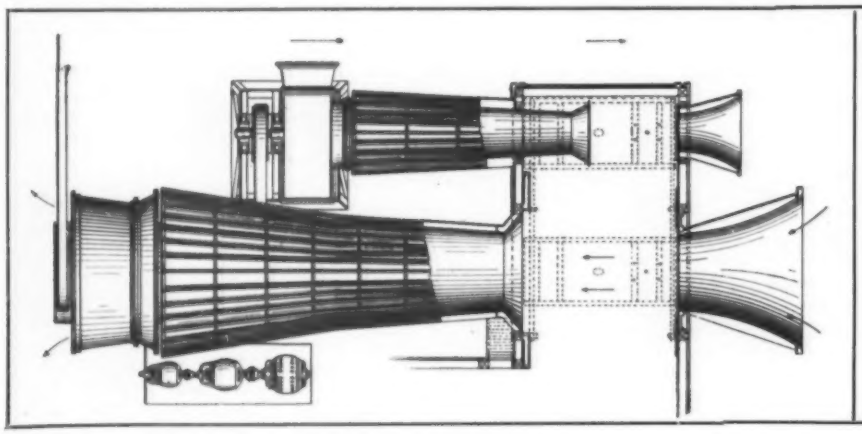
The Institute Aerotechnique de l'Universite de Paris is described in sufficient detail as to its material plant and operation in its prospectus, and in the following article published in the *Engineering Magazine* for October, 1911:

"The area of the site occupied is about 18 acres. The buildings comprise a central hall, surrounded on three sides by workshops, stores, laboratories, and a power house. In the central hall will be installed experimental apparatus devoted to the study of aerial phenomenal which will include a large fan, 6 feet 6 inches in diameter, and an aerodynamic balance, whereby the pressure of a jet of air on surfaces of various shapes will be determined. There will also be an air chamber supplied by another fan wherein it will be possible to measure the strength, the center of pressure, the components, and the resultant of the reaction of a current of air at any speed up to 65 feet per second. A tunnel similar to that used by Colonel Renard will also be erected for studying the stability of models. An arrangement for measuring the friction of air on surfaces of various natures when the air is moving at all velocities, an electric dynamometer for measuring the torque of propellers fixed in position, apparatus for studying helicopter screws, and a test bench for trials on the putput, endurance, and fuel consumption of aeronautical motors will also be installed. A closed chamber is to be erected, wherein the resistance of helical screws at speeds far in excess of those normally arranged for, and almost at the rupturing speed, will be investigated.

"In the chemical laboratory the study of light gases suitable for balloon work, will be carried on, and questions relating to their manufacture, purification, properties, etc., will be investigated. The chemical features of various envelope materials, the changes which occur in them under the influence of heat, light, and humidity, the properties and features of the various varnishes applied to render the material airtight and to preserve it, and similar subjects will also be studied. In the physical laboratory the instruments used in aeronautical work, the accuracy of their indications, their reliability and the modifications which are called for in their design to meet aeronautical conditions, will be investigated, while the densities and coefficients of expansion of light gases, and the best means of storing and transporting them will also receive attention.

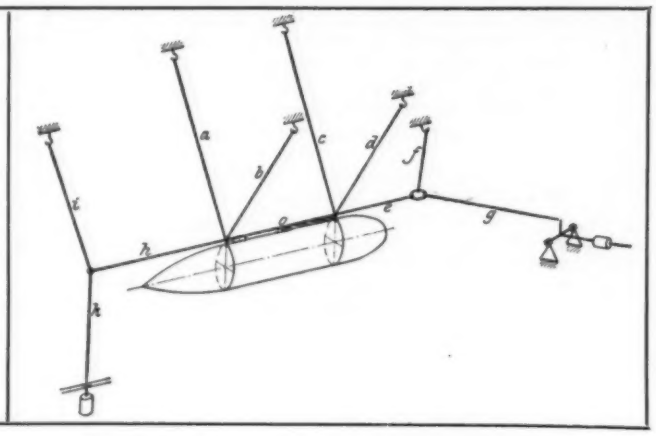
"A photographer's department has been provided next to the physical laboratory. In the workshops it will be possible to manufacture and repair all the experimental

[4] It may be noted, however, that Eiffel's and the English method of allowing a model to rotate about a vertical axis by supporting it on a step bearing is not very delicate, even when a jewel step is used. A more accurate way is to suspend the body from a wire, or float it on a liquid. The writer, in 1901, discarded the jewel pivot and supported his models on a fine steel wire, an oil damper being provided to deaden oscillations. With a float no damper is needed.



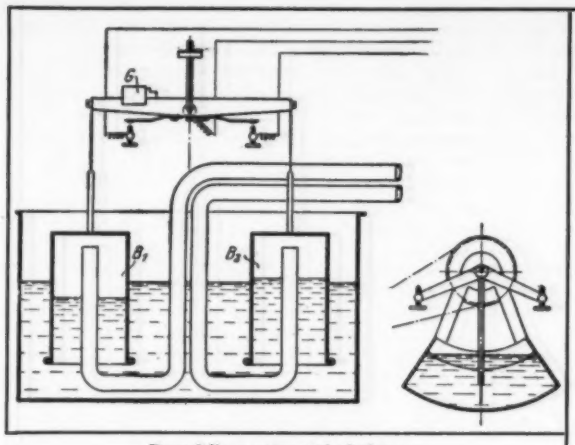
Plan of the Eiffel aerodynamic laboratory.

The large and small wind tunnels are shown side by side. Their diameter at the experiment room are 2 and 1 meter, respectively.

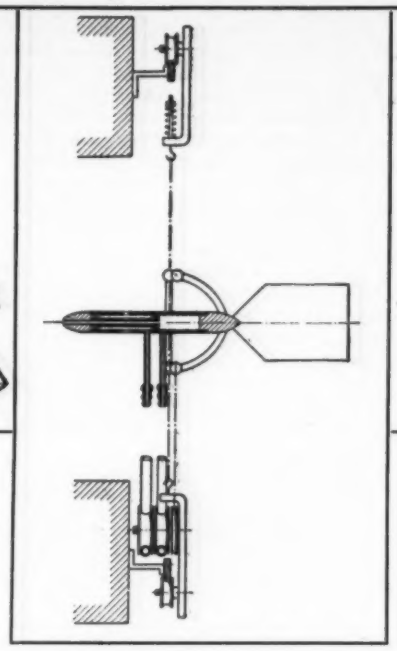


Prandtl's suspension for measuring head resistance.

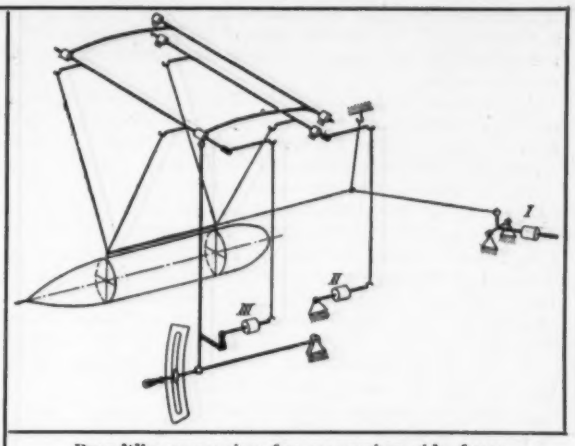
The model is suspended by fine wires and the tension of the mooring wire is measured by sliding weights in adjoining room.



Prandtl's monometric balance.



Prandtl's pressure-tube anemometer.



Prandtl's suspension for measuring side force.

appliances required by the institution. A part of one wing is reserved for the installation of machines designed specially to test the materials employed in the construction of aircraft. In the power house, situated at the west end of the building, are two vertical compound steam engines coupled directly to dynamos supplying power and light to the entire institute.

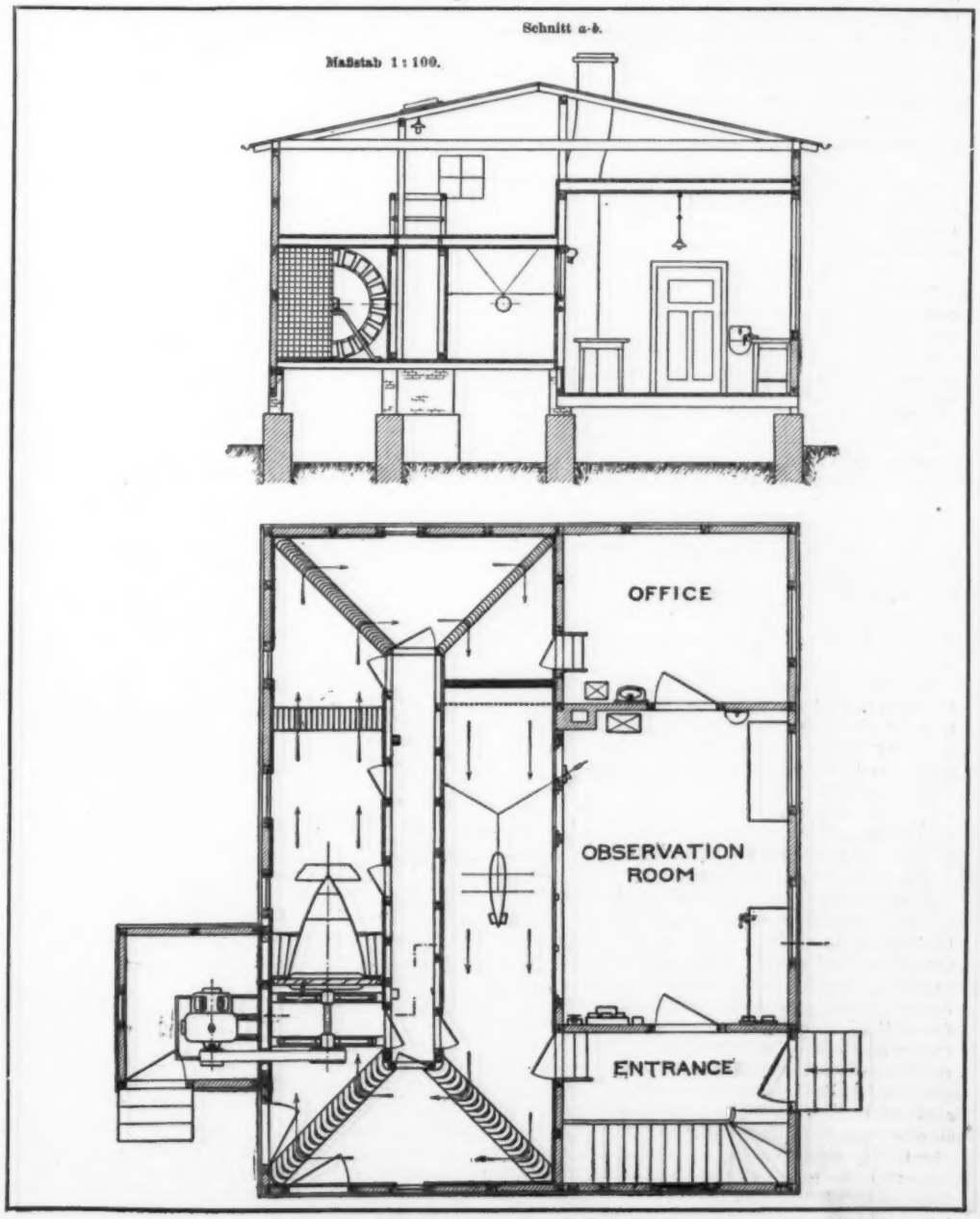
"One of the most interesting features of the institute is the provision made for certain large-scale experiments with planes and propellers. To this end a long, narrow strip of ground is laid out with a normal gauge railway about seven eighths of a mile in length. The rails are laid on oak sleepers, and are bonded in pairs by the aluminothermic process. The line is level over its entire length, with the exception of an incline at each end. At the starting point the line for a length of about 235 feet is given a slope of 1 to 100 to facilitate the starting of the vehicles. At the terminus a slope of half this amount, but extending over about 490 feet, is provided to facilitate the arrest and return of the carriage. On each side of the line and extending along its full length is laid an electrical conductor, whereby current is fed to the motor of the carriage. The return circuit is made by way of the rails. For the last 300 feet or so of the track an additional pair of rails is laid down alongside the running rails. On these additional rails, slippers carried by the vehicle bear so that over this distance, or at least a portion of it, the carriage skates instead of rolling. This facilitates stopping, and in addition furnishes a safety device in case of emergency.

"It is intended ultimately to have four electric carriages to work on the line described above. One has already been constructed, and has been used for a number of experiments. The employment of four carriages has been adopted in view of the fact that each series of experiments requires a different equipment of the carriage and different registering apparatus. If only one were used the time lost in dismantling and remounting it with each series of experiments would be very considerable. It is essential also that each vehicle should be specially designed to meet the conditions of the particular class of experiment for which it is intended. According to present intentions the first carriage will be used to measure the horizontal and vertical components and the resultant of the air pressure on surfaces of sustentation, whether plane or curved, simple or compound. The determination of the direction of the resultant, the center of pressure, its displacement when the angle of incidence is changed and the 'angle of attack' will also be undertaken with this carriage. The second and third vehicles are intended for experiments on propellers or tractors, one being used for the large screws employed for dirigible balloons and the other for the smaller aeroplane screws. The tractive effort, the power absorbed and the mechanical efficiency of each type of propeller will be determined at all speeds. A further important subject of study with these two carriages will be the effect of the translational motion on the putput and efficiency of the propellers. A comparison will be instituted between the efficiency, etc., of a propeller when rotating on a fixed axis and when moving with the same speed of rotation, but with various different speeds of translation. The fourth carriage will be specially equipped for measuring the resistance or 'drift' of the various parts of a flying machine.

"The weight of the first carriage is about 3¾ tons, excluding the motor, and a little less than 5 tons with the motor. The body of the carriage is built up of steel plates stiffened with angle irons and measures 20 feet in length and 6 feet 6 inches between the longitudinal members of the frame. Current is supplied to the motor by means of two pairs of sliding contacts carried in the side of the truck. The movement of the carriage is controlled from a lookout-post commanding the whole line.

"All the carriages will be furnished with appropriate measuring instruments. A chronograph will register the number of revolutions of the wheels in a given time, from which the speed will be deduced. In addition there will be a direct speed recorder registering the value of ds/dt at each instant of the travel. A recording watt meter will register the power furnished to the motor either on a time or a distance basis. One or more recording dynamometers will also be carried whereby the particular data being determined will be measured. The efficiency of the whole plant at all speeds, the fractional resistance of the driving and recording gear, the resistance to rolling of the carriage and the air resistance of its elements, will all be determined once for all, so that the power actually absorbed by the surfaces or screws under test may be readily determinable."

Full-scale measurements.—We saw a full-scale Blériot monoplane mounted on one of the electric carriages in such manner that its lift, drift and moment, or center of pressure, could be determined at one time, as it speeds across the field. The speed through the air is measured by means of a pressure-tube anemometer whose pressure collector is a Venturi tube, and has to be calibrated, since its readings are larger than those of a standard instrument such as used by Eiffel, Prandtl and others. The relative importance of such large scale experiments as compared with model tests, or full scale flights with instruments mounted on the aeroplane, has yet to be determined.



Plans of the Goettingen aerodynamical laboratory.

If of new type, the full-scale machine may be tested more safely on a car. The measurements of lift here are said to be in error about 5 per cent; the drift measurements are much less accurate.

A roundhouse, which measures 120 feet in diameter, shelters a whirling table, the extremity of whose whirling arm describes a circle 300 feet in circumference, and carries the models subject to aerodynamic study. This can be used in any weather, while the electric road can be used only at special times, and most effectively only during fair and calm weather. The whirling table, however, does not seem to be so popular in the leading aerotechnical laboratories as the wind-tunnel and large field track. It is not an indispensable part of an aeronautical laboratory, except where studies in circular motion are to be made.

Ancillary buildings have been erected on the grounds near the main laboratory, one for the director immediately in charge, another for the caretaker, who is also a workman assisting in the experiments.

The reports of the investigations are published in the *Bulletin de l'Institut Aerotechnique de l'Universite de Paris*. The annual issues for 1912 and 1913 are in the Smithsonian library.

Other French aeronautical laboratories, operating on a smaller scale, are worth mentioning, though unvisited by me for want of time.

The military establishment at Chalais-Meudon, in charge of the Engineer Corps, and under direction of Commandant Dorand, resembles the English Royal Air Craft Factory, in developing experimental air craft and making full scale tests; but it does not manufacture air craft on such a large scale, and does not compete with commercial firms in building for the government, but rather stimulates and helps them to do their best work.

The Conservatoire National des Arts et Metiers, corresponding to our Bureau of Standards, does some aeronautical work in calibrating instruments, testing materials and motors, and furnishes a "mouline Renard" —a standardized revolving bar with paddles at either end—for attachment to a motor to determine its power at various speeds of rotation.

By the use of automobiles on a smooth road Chauviere has tested screw propellers mounted above the vehicle and advancing at natural working speed, and the Duc de Guiche has measured the lift, drift and pressure distribution on aerofoils of considerable size. The accuracy of the automobile method has, however, still to be proved satisfactory. The Chauviere propeller experiments are now made at St. Cyr Institut; but the researches of the Duc de Guiche still continue, and are reviewed from time to time in aeronautical literature. The earlier reports comprise two volumes published by Hachette, Paris.

GERMAN AERONAUTICAL LABORATORIES.

The Göttingen aerodynamical laboratory, apart from the constructional and executive departments, is a one-story brick building, in size about 30 by 40 feet, comprising a wind-tunnel and two rooms, one for desk work, the other for instrumental observations. It stands alone, in a remote little meadow on the outskirts of the city, about 15 minutes walk from Prof. Prandtl's university headquarters. It is very cheaply constructed, lighted by electricity, and heated by a little stove in one office.

The wind-tunnel consists of a continuous closed channel, two meters square in cross-section, running round the four walls of the main room. Through this tunnel the air is forced in a steady closed circulation by a screw ventilator two meters in diameter, belt driven from a 30 horse-power electric motor placed in a little off room. As the blast from the blower is too fast along the tunnel walls, it is accelerated at the center of the stream by use of sheet metal fixtures placed in it near the screw, which also help to eliminate whirls. The air stream next passes through a honeycomb (Fig. 1), made of 400 equal sheet metal cells, each about 4 inches square and 20 long, the sheet metal being in two thicknesses, or two-ply, so that either cell can be constricted at will by spreading the cell wall inwardly. Actually, many of the cell walls were so constricted. In fact, the honeycomb looked badly distorted as if much time had been spent in adjusting the cells so that each should deliver the same amount of air. The adjustment once made assures, we were told, an air stream uniform in velocity at all points of a cross-section and at all speeds. One would think that a considerable change of speed would require a new adjustment of the cells to maintain uniformity. Emerging from the first honeycomb, the air passes through vertical sheet metal guide blades, each a double sheet and of turbine blade form, which turn the stream 90 degrees, without eddies; thence through similar blades giving 90 degrees more turn; thence through a much finer honeycomb to remove minor eddies. This last comb, placed just before the test part of the tunnel where the models are inserted, is made of sheet metal strips 10 centimeters wide reaching from floor to ceiling of the tunnel, and held in position by their mutual pressure, comprising among them 90,000 cells. The stream of air issuing from the last honeycomb is said to be uniform, and has a speed ranging up to 10 meters per second.

The measuring instruments employed are numerous; but as several of them resemble the ones already described, they need not be noticed. One favorite method used by Prandtl to measure the resistance of a model, say of balloon form, is to suspend it in the current by fine wires, and hold it against stream by horizontal mooring wire whose tension is measured in the adjoining room by means of a bell-crank and sliding weight. Very accurate measurements can be made without the mooring wires, if the weight and displacement of the model along stream be observed, as in my experiments of 1902. This method, as extended by Mr. Mattullath, has been adopted at Göttingen to measure the resistance of hulls, etc., held obliquely to the current. Prandtl's differential pressure gauge, consisting of inverted cups suspended from opposite arms of a balance, and dipping into a liquid, is like the one devised and used by me early in 1902, and found capable of measuring differential pressures truly to one millionth of an atmosphere, or less. This gauge was described in the *Physical Review* for December, 1903, half a decade before Prandtl's experiments.

The pressure distribution over model screw propellers having perforated hollow blades was measured by transmission through a hollow shaft to a pressure gauge. The screws were made of copper electrically deposited on wax models, and were then emptied of the wax by heating. To show the direction of air flow past the blades, sulphureted hydrogen was allowed to exude from perforations in their surfaces, and thus to stain them. The staining streaks extend fore and aft and very slightly outward radially along the screw blades.

The results of the experiments in the Göttingen laboratory have been published in various German periodicals, and in part translated and republished in *Engineering*, London, for 1911 and 1912, all of which are on file in the Smithsonian library. Particularly interesting are Prandtl's determination of pressure distribution on models of balloon hulls designed in accordance with hydrodynamic theory; also his measurements of the resultant wind force on oblique hulls and wing forms by the method devised and used by H. Mattullath in 1902; also the resistance of wires and ropes, etc. Prandtl found in fair shapes a large difference between total resistance and the pressural resistance, and ascribed the difference to skin-friction; but this he did not measure directly.

The Deutsche Versuchsanstalt für Luftfahrt zu Adlershof comprises one main building used for offices and full-scale aeroplane testing; one used for construction; and five small houses each containing an engine testing apparatus. In addition to this plant, it is intended to fly full-scale machines with measuring instruments, and to mount large apparatus on an aerodynamic car pushed by a locomotive on a railway.

The laboratory of the main building is a large square room with a tower in its center 100 feet high, on top of which wind observations may be made, and inside of which suspension cords run down to support an aeroplane just above the floor, to determine its moment of inertia. In a corner of the room an aeroplane inverted and weighted with sand, as in Langley's method, was under test for stress and strain of its wing framing. In another corner was an apparatus for measuring the force applied to the controls of an aeroplane by pilot in practical flight. This instrument may help to determine the most suitable mechanism for a standard control.

The shop and the engine testing houses contain nothing that need be reported. The engine torque and thrust were measured by ordinary mechanical methods, and no special apparatus was used to furnish a stream of cooling air, as in the British laboratory.

Other German aeronautical laboratories worth passing mention are: the testing department of the Zeppelin Airship Company; the aerodynamic laboratory used by Prof. Reissner of the technical high school at Achen; the laboratory in charge of Major v. Parseval in the high school at Berlin; the experimental plant of Prof. Dr. Fr. Ahlborn, at Hamburg. The Zeppelin laboratory is not, under any consideration, open to visitors from abroad; and as to the others just mentioned, I had time only for a brief visit to Ahlborn's place. Ahlborn's experiments have been confined mainly to determinations of flow about models in a tank of water. The results are well portrayed in numerous excellent photographs and publications, the best of which are in the Smithsonian Institution. His apparatus and photographs and those at the National Physical Laboratory in England are, for hydromechanical studies, the most instructive that have yet come to my notice, except perhaps the more restricted ones of Hele-Shaw. For stream-line delineation in air, however, the classical apparatus and methods of Marey have not yet been surpassed, though more precise instruments of this nature are much to be desired.

To Make Nottingham a Port

THE Manchester Ship Canal now being a paying venture, Nottingham is desirous of taking in hand the canalization of the Trent, with the idea of emulating, albeit on a smaller scale, the excellent example of Cottonopolis.

The scheme is already well advanced, and a bill will be introduced into Parliament to secure legislative sanction for the Nottingham municipality to expend the necessary £160,000 on the work—already begun in a small way by the Trent Navigation Company.

The directors of the company, with the limited resources at their disposal, have carried out works of far-reaching importance beyond Newark, enabling boats of from 100 to 120 tons to be brought thence from the mouth of the river, but once the confines of that historic borough have been reached something in the nature of a deadlock occurs, all the merchandise consigned to Nottingham or beyond having, at necessarily increased cost and sacrifice of time, to be transferred into smaller boats of 20 to 30 tons capacity. It is upon the tortuous and at present difficult stretch of the Trent between Nottingham and Newark, a distance of about twenty miles, that the corporation contemplates an expenditure of £160,000, and although, apart from railway and other conflicting interests involved, there are opponents of the scheme in Nottingham who predict that it will prove something in the nature of a white elephant. The ratepayers recently at a statutory meeting supported the policy of the council, the anticipation being endorsed that with the carrying out of the contemplated improvements in the navigation a satisfactory volume of traffic and consequent revenue would be annually forthcoming.

No formidable engineering difficulties stand in the way of completing the scheme, which is destined to form a substantial link in the chain of improved inland water communication which the Royal Commission on Inland Waterways has long been anxious to establish. The junction with the Trent and Sawley canal marks at present the upper limits of the company's navigation. Down the river there are junctions with the Loughborough navigation, affording means of reaching Leicester and onward through the Grand Junction Canal to London. Northward the company's authority ends at Gainesborough, the Humber Conservancy Board possessing jurisdiction from the mouth of the river to that center of engineering activity. The Newark Corporation, by a generous expenditure upon the river for three and a half miles of its length in the neighborhood of that town, has already set an encouraging example to the capital or county, the works there forming a portion of the undertaking leased to the company, who expended a large sum upon the construction of the new Cromwell lock completed between 1909 and 1911, possessing a length between gates of 186 feet and a width of 30 feet, and being so constructed that there would never be less than 6 feet 6 inches of water running through it. At an earlier date the Newark Trent lock was deepened by the company, giving sufficient breadth and length also to accommodate boats of 100 tons at all seasons.

The work which the Nottingham corporation has now in contemplation includes a complete revolution in the river between Trent Bridge and Newark by an exhaustive process of dredging, which it is estimated will cost £55,000, and the construction, at an expenditure of £76,300, of new locks at Stoke, Bardolph, Gunthorpe, Hazelford, and Holme Pierrepoint, £10,000 of the total outlay involved being allowed for the work in relation to the Newark nether lock. In the two miles of water leading from Trent lock at Nottingham toward Newark not much remains to be done to meet the requirements of boats 100 tons, the major portion of the expenditure being necessitated on the stretch fourteen and a half miles between Homelock and Fiskerton. This part of Trent is very shallow, and at points exceedingly rapid, the depth of the water available for navigation at times of exceptional drought seldom exceeding 2 feet 3 inches, while the vertical fall in the water level is no less than 21 feet, equivalent to 17 inches per mile. After leaving Fiskerton no great amount of dredging remains to be done. It is proposed to make all the new locks of the same size as that at Cromwell, the object being to allow a tug and its train of boats to be passed at the same time, and thus to get rid of the serious delay entailed by having to "pen" each boat separately. As four vessels could then be passed at the same time through a lock of the size proposed, this would be equivalent to about 300 tons of cargo.—*The London Daily Telegraph.*

It is now stated that by using a small percentage of the tar from oil gas as a binder coal dust can be satisfactorily briquetted, although explanation is given why this kind of tar should give successful results where all other kinds have failed.

The Protection of the Strong

A Discussion of the Working of Insurance Laws for the Protection of the Poor

MURMURS of dissatisfaction occasionally arise over the working of the German insurance laws for the benefit of the poor. There is especial difference of opinion as to the results of the legislation regarding the sick benefit fund, the laity and the medical profession looking at the question from two totally different points of view. The matter is discussed in a recent number of the German journal *Umschau* by a Dr. Jens Paulsen, who, after pointing out the trials of physicians in conforming to the laws concerning the sick insured poor, goes on to a general review of the whole subject of the preservation of weaklings, to which so much attention has been given by the German government during the last thirty years.

The sick-benefit insurance laws have a wide-reaching influence in Germany, for when the dependents of the insured are included 94.4 per cent of the population of the country are affected. Dr. Paulsen's complaint as regards this fund is that the working of the laws have enormously increased the labors of physicians while making them dependent on a few government officials; that, in short, the profession has had a most unpleasant disillusion. In former days the attending physician was the free choice of the patient, who selected the man in whom he had confidence; now the fund steps in between the two and assigns the patient and attending physician to each other. Owing to the great number of people who are obliged to call on the insurance fund in illness, this virtually makes a large part of the medical profession dependent for success in their calling on the good-will of a few administrators of the fund, hence the combats between the two sides. The writer claims that every physician who conforms to certain conditions laid down by the fund should have the right to care medically for any patient who might desire him, as was customary in days before the fund existed. The other main grievance is that the fund has practically made all physicians in its employ health officers, who must spend the greater portion of their time in filling out blanks and making reports, the result being that such physicians are compelled to employ secretaries to their pecuniary detriment. For every patient, whether a case of serious illness, or a mere trifle as chapped skin, blanks containing innumerable questions must be filled out and certificates drawn up for the patients containing all forms of grants, from the right to the insurance money or permission to go out walking. The writer declares that he himself has had to fill out over a hundred different kinds of blanks, and it is only after this secretarial work is completed that the physician can give his attention to the medical care of the patient.

The patient is also unfavorably affected. He has to run to the physician for every trifle, as it is to his pecuniary advantage to get medicines free, and a medical certificate is generally required for absence from work. Thus, the poor are trained to dependence and helplessness in petty ailments for which formerly they would have sought remedies for a few pennies at an apothecary's, lose the sense of dishonor in living off the public funds, and fall often into the demoralizing habit of playing sick. To meet all these small demands the physician is frequently expected to be at his office in the evenings and on Sundays, so that the patient may not lose time from work. Consequently, the doctor has seldom time to keep up with the scientific advances in his profession, is often obliged, by the inordinate care which must be given to insignificant ailments, to neglect serious illnesses, and, what is probably the crux of the whole matter, is rarely paid for individual cases, but only a small lump sum for all the patients that must come under his care.

The main benefit claimed by social reformers from this system is that thereby the beginnings of illness are immediately treated and serious dangers to health are checked. The objections made by physicians are those just mentioned with the addition that the enormous sums expended by the fund are too largely paid out for petty cases while insufficient money is allowed for serious cases. In the opinion of the writer, inner reforms allowing more independence of action are required rather than a complete reconstruction of the benefit fund laws. The changes suggested by the medical profession have been rejected by the authorities and are regarded as not proved by the files and statistics. This Dr. Paulsen considers a blunder, for that which is essential cannot always be weighed and measured. The physician should be allowed more independence in practise and should not be forced to waste his strength on blanks and trifles. It would be well to apply to the insured the measures now adopted by private insurance companies, which no longer compensate small ailments as formerly and make the insured themselves take a certain part of the risk. It would be better if the patient had to pay a part of the cost of medicines, or even share in the expense of medical attendance. This would increase his interest in and respect for the work of the fund, for what costs nothing is seldom appreciated. Moreover, the son of well-to-do parents, who happens to have a small salary, should not be entitled to the benefits of the fund, nor should a young fellow receive the same insurance money as the middle-aged father of a family, because both happen to draw the same wages.

Similar difficulties have developed in the administration of other branches of social legislation, as in accident insurance; and attention is called to the increasing burden laid on large cities by the demands for social improvements.

The writer then takes up the further question whether it is possible to attain a healthful condition of the entire population by a development of the insurance laws, that is, by assuring the expense of prompt and sufficient care in cases of ill-health, in addition to the present measures preventive of the spread of disease. Preventive measures have removed the danger of certain contagious diseases, as the plague, smallpox, and cholera. Safeguards against accidents and inspection of workshops prevent industrial mishaps. Phosphorus poisoning of workmen is avoided by forbidding the manufacture of phosphorus matches. All these evils cause injuries to health through purely external influences. When it comes, though, to an attempt to uproot the tendency to illness inborn in the individual human being, the matter, in the opinion of the writer, is very different and universal biological laws come into play. The original cause inherent in the individual cannot be removed, and favorable external conditions develop it into illness. "For instance," says Dr. Paulsen, "a physically vigorous soldier, who is also apparently sound mentally, becomes in a war unbalanced in mind from the same fatigues and psychical impressions to which his comrades have also been exposed. This mental affection would probably not have appeared if he had lived continuously under favorable conditions. In such a case, consequently, the social preventive measures would have obviated the outbreak in times of peace, but could not in the least have done away with the inherited tendency."

The layman knows that peculiarities of mind and character and insanity are largely hereditary, but seldom thinks that physical illnesses are also frequently the result of inherited inferiority of physique; that a person with such hereditary tendencies can rarely fight out the struggle of life, or only does so under the constant aid of the benefit institutions, with the help of which he drags out a weary and disheartened existence.

There are many more persons thus heavily weighted than is commonly believed. As examples might be mentioned the army of people suffering from nervous diseases, gout, diabetes, etc. Hardening of the arteries is also hereditary in some families. Many sufferers from tuberculosis have also inherited the trouble, while an anatomical predisposition must be assumed at times for appendicitis.

In many cases of illness it is evident that the ill-health is not entirely from external accident. A good example is to be found in the mentally retarded. There are beings who have remained in a childish condition both physically and mentally, or, as more frequently happens, in whom one organ or one set of organs have never fully developed. Thus, it is common to find a small heart which works all right when not overtaxed, but which breaks down in illness or when much is demanded of it. It is like a small pleasure auto which has been turned into a motor van for heavy loads. To such persons may be added to the great throngs of those who are constitutionally weak on account of the alcoholism or syphillis of parents, as well as those who have contracted such diseases themselves. Experienced observers, therefore, believe the opinion to be correct which holds that a third of the population of Germany is imperfect in health.

The physician can often do no more than mitigate the sufferings of persons thus burdened. The extreme cases fill the endless succession of insane and other asylums, the homes for the crippled, deaf and dumb, and blind, all of which institutions yearly increase in number and size. The lighter cases, those able to work, are the persons who, above all, lay claim to the aid of sick benefit insurance and other social organizations. It is these classes of people who are the great source of expense to benefit funds and charities.

Consequently, the present social provision for the care of the weak often leads to the maintenance of the unhealthy elements of society at the expense of the healthy, and gives the former greater opportunity to reproduce their ailments in offspring. "Frequently," continues the writer, "children of the tuberculous are found who were born in the period after the first treatment by the insurance benefit. This treatment has often only slightly prolonged the life of the invalid, while it has aided in the bringing into the world of a large number of children. In the same way the cure of drunkenness is advantageous to the individual both economically and as regards health, but results in a deterioration of the population through the children born after the cure who have hereditary weaknesses. It would be a good thing if the insurance offices were to issue information as to the number of these children. Thus plainly the weaklings are favored in their perpetuation at the expense of the healthy through our efforts to protect them."

At the same time difficulties are often thrown in the way of the perpetuation of the good qualities of the healthy. In the higher circles of society many marry late or not at all. The German officer desiring to marry is obliged to inquire first about the fortune of the proposed wife, and not until afterward as to health and abilities. It is not merely training and examinations which can raise a class of society in the world; there is something also to be learned in life afterward. While a change of conditions described is greatly needed, it will be difficult to bring about, because it demands a knowledge of biological principles which the majority of even the educated people lack. There is still little understanding of the fact that inner causes contribute far more to health and good fortune in life than outer conditions. Even physicians lay too great a value on external factors. Another difficulty is the undue estimation of personal liberty. It should be better understood that the individual, as a citizen of the state must subordinate his personal life to the good of the whole.

Although the weak should be protected and cared for in every way, yet the demand must be made upon them in return that they cease to have children when it is medically proved that such children will cause deterioration of the race, and means should be taken to enforce these demands. On the other hand, marriage must be made easier for the valuable elements of the race, especially for those of mental ability. These problems are difficult and their full solution may never be attained. It would, though, take too long to wait until the entire nation came to understand the matter, for that would be to expose the country to the fate which all civilized peoples have suffered that have gone to pieces since the days of Rome, because the strong members of the population failed to perpetuate themselves, while the inferior part of the nation increased at the expense of the healthier and more valuable.

British Metals and Alloys

THE cutting off of certain engineering supplies which formerly came from Belgium and Germany has been a very serious matter in many branches of the industry. The automobile manufacturers were particularly hit by the absence of light steel stampings and castings; so much so, in fact, that special meetings of the Institution of Automobile Engineers were held in London, Birmingham, and elsewhere, to discuss the position with a view to inducing British manufacturers to lay down the necessary plant for the production in large quantities and at a reasonable price of the various parts of which there was so great a shortage, and which heretofore have come from abroad.

Encouraged by the success that has attended this enterprise, the makers and users of metals and alloys that formerly came from Belgium, Germany, and, in fact, from foreign sources generally, arranged for a meeting in Birmingham. At this meeting there were extensive exhibits of all kinds of British-made metals and alloys both in the worked and unworked states. These showed very clearly that it is no longer necessary for manufacturers to depend upon foreign supplies. Samples of the various metals used in the production of alloy steel and pure nickel in the form of wire, crucibles, cylinders, and so on were exhibited, together with rarer metals, such as cerium (used for automatic lighters of the friction type) and tungsten. The latter metal was largely imported from Germany, but is now being made here in large quantities, particularly for electric lamps and for hardening steel.—*The London Daily Telegraph.*

The "Chestnut" Viaduct across the Rhône.

The Furka Railway

A New Alpine Railway from the Rhône to the Rhine

By Dr. Alfred Gradenwitz

THE district traversed by the Furka Railway, which connects the Rhône with the Rhine, has the most varied attractions in store for the genuine lover of Alpine scenery; moreover, the country bordering upon the new line is historic ground of the Swiss Confederation. The scenery along the actual line, although of a sterner kind than that of many parts of Switzerland, has nevertheless certain qualities, difficult of definition, which give it a stronger and more permanent hold on the affections and imagination than the milder contours and more luxurious growths of other regions. The mountain passes in the surrounding district—the Gothard, Simplon and Grimsel—are the most famous in the Alps. As for the Furka itself, below the summit of which the new line runs, without, however, disfiguring its natural beauty, this is one of the most beautiful of Alpine passes.

The new railway starts from the old Valaisan town of Brigue, the well-known railway junction for the Simplon and Lötschberg lines. Brigue is situated in the Rhône Valley, a valley more than 100 miles long, which leads from the Rhône Glacier to Lake Geneva, characterized by the long, straight line of the turbid waters of the river and by long straight roads bordered by equally long rows of Lombardy poplars. Every town and village, almost every hamlet, has its history, usually one of blood and fire, battle and sometimes murder.

Immediately behind Brigue station, the line passes below the Federal Railway and crosses the Rhône on a bridge of its own, reaching the ancient village of Naters, which, being occupied by a colony of Italian tunnel workers, is distinctly picturesque. On one side of the valley is the Furka line, and on the other the Simplon line, with the entrance to the longest tunnel in the world. For a time the line follows the old Furka Road, passing through a fertile valley, where fruit trees and gardens are plentiful. Spanish chestnuts grow about the hillside, and Indian corn and melons flourish in the gardens in summer. After crossing the Massa, one of the turbulent tributaries of the Rhône, the railway reaches Z'Matt-Bitsch and follows for a while the concrete conduit which supplies water for operating the turbines of the Simplon tunnel.

Throughout most of the valley, in fact, throughout the greater part of the Valais, the fields are kept green, even in a hot, dry summer, by means of a multitude of little irrigation canals, mostly of great antiquity. After leaving Mörel, the line passes over two of the thirty-four viaducts of the Furka Railway, beside which there are thirteen bridges and two loop tunnels.

The Rhône is now crossed on the picturesque "Chestnut" Viaduct, after which the line rises considerably, the first cogwheel section beginning here. This leads toward Grengiols, which is left high up to the right, and on a lofty viaduct about 330 feet in length, crosses the road and river, reaching a high mountain slope at right angles to the straight valley. Round this obstacle the Rhône turns in a large loop far below; the road (in the south) winds slowly upward in zigzags, and the railway disappears to the north in a loop tunnel 2,000 feet long, reaching the height of Deisch, by another cogwheel section and tunnel.

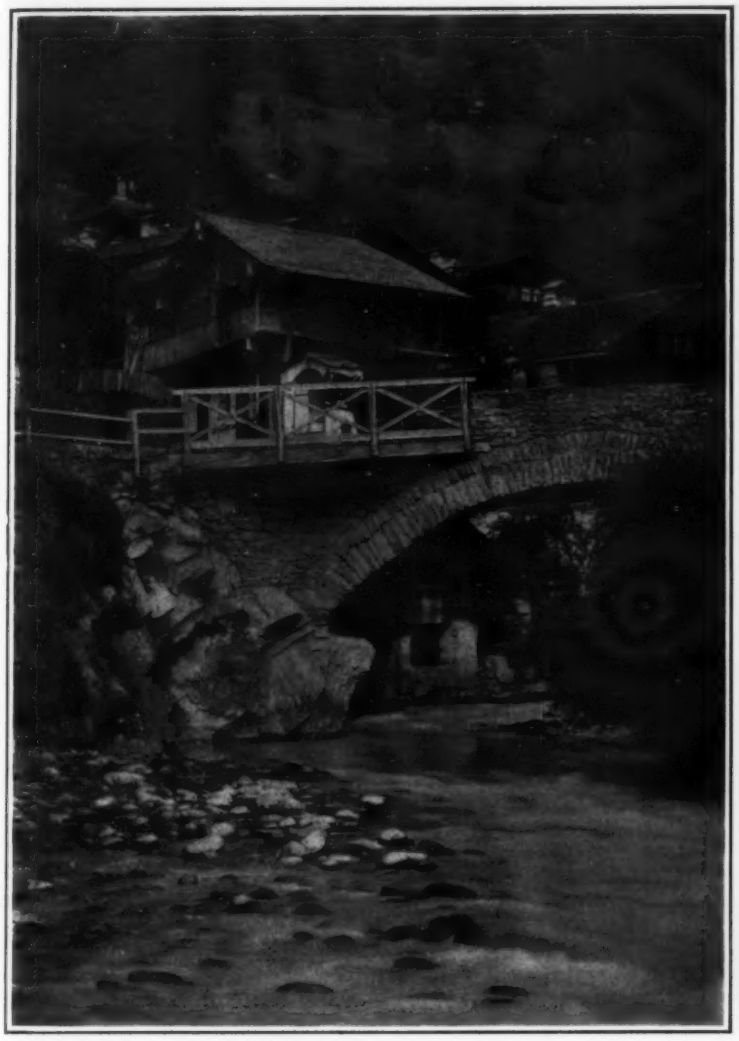
The Fiesch Valley is now entered, through which runs the Fieschbach (or White Waters), a glacier stream and a tributary of the Rhône. Several more viaducts are then crossed, before the summer resort of Fiesch (3,493 feet altitude) is reached, the starting point for a number of mountain excursions.

After leaving Fiesch, the Furka Railway proceeds for some way through larch and pine woods. Looking backward, there is a fine view of the Weisshorn *arête* and cone, and glimpses of the Diablon and the Fiesch glacier. The line then continues in a wide curve, again in a cogwheel section, with a splendid view on the Fiesch Glacier and the village of Bellwald situated at a lofty height, and after crossing the Fieschgraben Viaduct, climbs up the mountain slope. Passing close to the Rhône, we soon notice Niederwald, half hidden behind a fold of the mountain, and rapidly pass through a long succession of small hamlets, all turned on the northern slope toward the often sparing sun.

The valley widens out more and more, and no little spot is left uncultivated, though the rude climate in those heights (3,900-4,600 feet) only allows grass and a little rye, barley and flax to thrive. One of the next stopping places is Ulrichen, a military station, facing the Eginental, a valley leading to the well-known passes of Gries and Nufenen, used in olden days, like the Albrunn Pass, by Italian wine carriers transporting wine to the cellars of Berne. Plans have been made for constructing a railway from Ulrichen over the Nufenen Pass to Airolo on the Gothard line, thus effecting a connection between the Valais and Ticino. The Furka Railway also touches Oberwald (4,497 feet), the highest village in the Upper Valais, and a summer resort. This is the furthest point to which the railway runs in winter. The line now enters the narrow gorge which terminates at Gletsch (5,778 feet), situated at the bottom of the Rhône Valley, with the Rhône Glacier in the near distance, the Furka Pass on the right, and the Grimsel on the left. Gletsch is the celebrated crossing of the Grimsel and Furka roads, the former of which still is the uncontested realm of the mail coach.

Before reaching the Furka tunnel proper, rather over a mile in length, which runs immediately below the Furka Pass, at 7,138 feet altitude, there is Muttbach, whence a good road leads to Hôtel Belvédère and to the upper edge of the Rhône Glacier. From the summit of the Furka there is a splendid view on the Bernese and Valaisan Alps on the one hand and the Ursern Valley with the Urner and Gothard peaks on the other. The Mutthorn can thence be reached in 3 hours. Beyond the Furka Pass there is Furka Station, whence a new military road at Tiefenbach reaches the Furka road proper.

The railway now descends the slopes of the Reuss, here but an insignificant stream. Shortly before the Aegerton chalets are reached the Wyttenwasser Valley opens to the right, leading to the glacier of the same



Picturesque Fiesch, with Alpine stream in foreground.

Lofty viaduct crossing the Rhône near Grengiols.

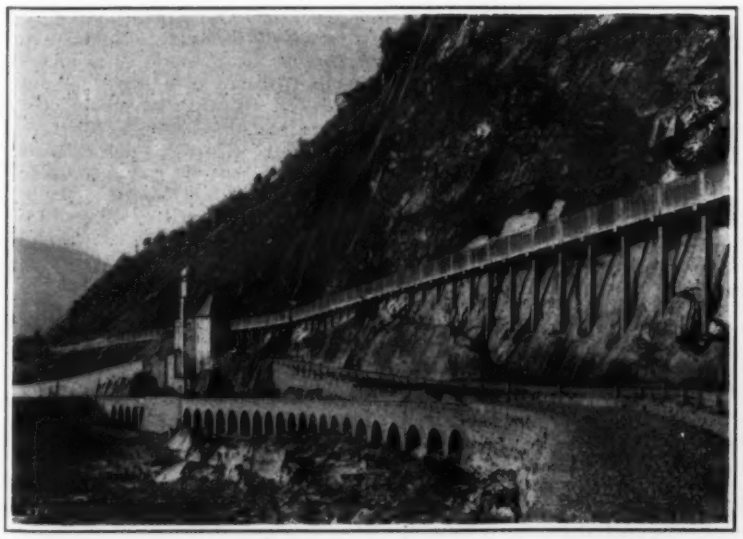
name. The village on the left is Realp (5,000 feet), a pleasant little place in a plain, which is a stretch of dazzling snow in winter, and of flowery meadows in summer. We now reach Hospental, whence the Gothard road branches off southward, and soon after Andermatt, the station of which is to serve at the same time for the Schöllenen Railway (Andermatt-Göschenen) now under construction. Immediately behind the station, the Furka passes over the Gothard tunnel.

We now take another lofty ascent—in three loop tunnels—to the summit of the Oberalp Pass (6,742 feet), whence we enjoy the wonderful scenery of the green Urseren Valley with the surrounding mountain giants. The pass here forms a lengthy defile with a melancholy little lake. At the end of the Oberalp Plateau there rises the Calmot (7,590 feet) the eastern foot of which is encompassed by a number of military buildings. To the right there is a footpath leading into another country and another valley, that of the Rhine, in the Grisons, where Romansch-speaking people live.

The railway continues its course on a slight slope high above the road and affords a welcome opportunity of admiring the "Piz" or peaks of the western Gothard massive. Below our feet, we see once more human dwellings, chapels and somewhat lower, on the banks of the foaming Rhine, a picturesque group of villages—Sul, Crestas, Selva—wholly embedded in flax and barley fields. As far as the eye can see, there is an endless stretch of verdure and woods. Beside every cluster of *châlets* will be noticed certain curious, wooden roofed structures, the use of which is not at first plain; but at this altitude, and with so little warmth, the corn, although it will consent to grow, cannot be ripened, and therefore it is hung up under the shelter of a roof, to be properly dried and continue its ripening process. The struggle for life here is keen indeed, but as the descent into the Grisons proceeds, the scenery becomes every mile less severe, the line often running through pine woods, and the valley broadening out greatly. The principal place before Disentis is reached is Sedrun, at 4,736 feet altitude, shortly behind which the railway traverses a broad sweep of flat, fertile land, with paths leading in all directions to the small brown-roofed villages dotted about in all the more sheltered corners.

Disentis, at 3,760 feet altitude, the terminus of the Furka line, probably takes its name from Desertinum (desert). Its most striking feature is the white Benedictine abbey, the oldest Benedictine foundation in Switzerland, which was probably established in 614, by the Irish monk Sigisbert. The abbots of Disentis acquired in the middle ages much power and importance, and one of them even attained to the dignity of a prince of the Holy Roman Empire. Besides being a place of great historical interest, Disentis is a spa, possessing the most powerful radio-active springs in Switzerland, and an excellent center for mountain excursions.

On account of local conditions the idea of operating the line by electricity had to be abandoned, steam being found more economical. The Furka Railway is 97.1 kilometers in total length, of which about 32 kilometers, with gradients of 70-100 per cent are cogwheel section on the Abt rack system, which allows a remarkable speed to be obtained.



Above the railway is a flume, carrying water to operate the electric plant of the Simplon tunnel.

The viaduct leads to the mouth of a long loop tunnel; the carriage road zigzags above.

Atoms and Ions—V*

A Comprehensive Discussion Especially as Related to Gases

By Sir J. J. Thomson, O. M., F. R. S.

Continued from SCIENTIFIC AMERICAN SUPPLEMENT No. 2055, Page 327, May 22, 1915

AT the Royal Institution, Sir J. J. Thomson, O.M., F.R.S., in delivering the fifth lecture of his course on "Atoms and Ions," recalled that on the last occasion he had referred to the slight conductivity which air possessed, and maintained even when confined within a closed and thick-walled vessel. In no way whatever was it, he said, possible to reduce this conductivity below a value which corresponded to the production of about four ions per cubic centimeter per second. If, instead of using air inclosed in a thick-walled vessel, a sample of free air was taken, the conductivity was very much greater than corresponded to the above figure. In fact, with air in its normal state, the number seldom fell below eight ions, and might rise to a much higher value. This additional conductivity was due to the radioactive constituents of the earth and atmosphere. These gave off emanations which were capable of ionizing a gas, and to the presence of these emanations was to be attributed all the conductivity in excess of that corresponding to the production of four ions per cubic centimeter per second. As would naturally be expected, this added conductivity showed considerable fluctuations, being dependent on the presence of a gas which had originally come out of the earth and been carried by the winds to the site of the experiment. The quantity of this constituent present in the air had been measured by Satterly at the Cavendish Laboratory daily for nearly a year, and he had found that its amount ranged from a minimum corresponding to the production of one ion per cubic centimeter per second to a maximum some ten times as great. Satterly had tried to establish some connection between the amount of this constituent present and the state of the weather. But no very close connection was apparent, the weather, whether wet or dry, calm or windy, making little difference to the conductivity. In fact, the gas sampled at any one time might have traveled hundreds of miles. The constituent responsible for the extra conductivity, though not permanent, could last a week or so, and hence the conductivity of the air examined at a particular time might have been acquired a week or two previously. In this connection it was therefore the atmospheric conditions at the sources of supply, rather than those at the testing place, which might affect the conductivity. Hence, no very close connection was to be expected between the conductivity of the air and the state of the weather, and none was apparent. When, however, the course of the air was traced back, for some time previous to the test, by means of meteorological charts, it turned out that in air which had traveled over continents the amount of emanation was much higher than that in air which had come from over the sea, the difference being very considerable. Another point established was that, when the barometer was falling, there was a tendency for the conductivity of the air to rise, due to the liberation of gas from the earth under the diminished pressure.

Mr. Satterly further found that the gas sucked out of the earth through pipes sunk to different depths in various parts of Cambridge was a very good conductor, being about two thousand times as conductive as ordinary air. This was due to the fact that the radium constituents of the soil were constantly giving off emanations, which collected in the pores of the soil, and, when sucked out, this emanation produced a gas which was quite a good conductor of electricity. Mr. Satterly found, moreover, that the marsh gas liberated on stirring up muddy ditches was also a very good conductor, as it brought with it the emanation which came off from the radium constituents of the mud. The amount depended, of course, on the quality of the mud, but very often marsh gas thus obtained had a very large amount of conductivity. From experiments made above land surfaces it appeared that the quantity of radium emanation in the air was sufficient to produce per annum and per cubic centimeter of air, 3×10^{-17} cubic centimeters of helium. The amount of helium actually present in the air was 5×10^{-6} cubic centimeters per cubic centimeter of air. He would not, Sir Joseph continued, divide the one figure by the other in order to determine the age of the earth, since a good many intermediate steps were missing between the emanation and the helium, which would have to be made good before a calculation of this kind could be justified.

In the last lecture he had alluded to the ease with which sodium and potassium and the alkaline metals generally came off (with a positive charge) from surfaces. He had meant to illustrate this experimentally, but the tube had cracked. He would not, however, make good the omission. The only peculiarity about the tube used lay, he said, in the electrodes. The positive electrode consisted of a piece of tubing, the upper end of which was tightly packed with a mixture of sodium iodide, sodium bromide, lithium iodide, and lithium bromide. A wire embedded in this mixture formed one terminal of the tube. The cathode consisted of a wire, which encircled as a spiral the tube forming the anode. When the discharge passed, the salt mixture was heated, and gave out rays consisting of atoms of sodium and lithium, which moved fast enough to give the characteristic colors of these metals, viz., the yellow of sodium and the red of lithium.

Proceeding, the lecturer next discussed the means by which solids and liquids which were ordinarily insulators might be made conductors. This could be done, for example, by means of the Röntgen rays. The resultant conductivity was in no case equal to that produced by the same means in a gas, but it was still quite appreciable. In the early days of Röntgen radiation he had himself observed that these rays would render conductive a mixture of vaseline oil and bromine, which ordinarily was a very bad conductor. Similarly, hexane exposed to radium became quite a good conductor of electricity. Jaffe had in this case measured the number of ions produced and their speed, and also the rate at which ions of opposite sign combined to form new systems. In some respects hexane was more satisfactory to work with than gases, as, although the conductivity was smaller, the results were found to be more regular.

The Curies had shown that insulating liquids and solids exposed to the radium emanation also became conductors. McLennan, again, had found that when exposed to the influence of polonium, liquid air would conduct electricity. He would have liked, the speaker continued, to have shown this experiment, but owing to the difficulties arising from the condensation of moisture in the apparatus, and consequent loss of insulation, the plant required was too cumbrous for use in a lecture experiment.

Dewar had shown that, normally, liquid air was an insulator, yet McLennan now found that it would conduct when exposed to polonium. The speaker would, he said, use polonium to show that under its influence paraffin would become a conductor. To this end Sir Joseph placed a sheet of paraffin paper on a copper plate coupled to an electroscope, and on top of this paper laid another sheet of copper, on one side of which was a deposit of polonium. He showed that the leakage from the electroscope was about three times as fast when the polonium deposit was next to the paraffin as when the plate was reversed upside down.

There was another substance, the lecturer continued, which became a conductor when exposed to Röntgen rays, but he would not claim that this was a simple case of ionization, although probably closely connected therewith. He referred to the action of Röntgen rays on a selenium cell, which under the action of the rays had its resistance very largely reduced. The cell was made by cutting a series of equally-spaced notches on the opposite edges of a strip of mica, the most convenient plan of doing this being to clamp the mica between two pieces of brass, turn up the whole on a lathe, and finally cut a screw-thread of 1 millimeter pitch. Around the strip thus formed were wound two coils of wire, the two wires resting in alternate notches. The whole was covered with selenium and warmed until the selenium flowed over and filled the interspaces between the two windings. It should be noted that it was only the crystalline form of selenium that was sensitive, and the attainment of this state was indicated by the appearance of the selenium, which in the crystalline condition was slate-colored.

Taking a cell thus formed, the lecturer placed it in a light-tight box, coupling up one coil to a voltaic cell, and the other to the terminals of a galvanometer. On exposing the box to the action of Röntgen rays he showed that the deflection of the galvanomter was notably increased, the resistance of the cell being, in fact, diminished to about one third of its original value. Great as was the effect of the Röntgen rays on the cell, that of light was, he continued, very much greater, a lighted match brought near the cell causing a very large deflection. Many practical applications of this property of selenium has been proposed, including a method for the transmission of photographs telegraphically.

Resuming, the lecturer said that it would be seen from the foregoing that by the action of appropriate agents we could get conductivity in liquids and solids as well as in gases. Indeed, we should expect that it ought to be easier to effect a separation of the positive and negative charges in the case of liquids than in that of gases, or, rather, than in the case of the individual molecules constituting the gas. The electrons or corpuscles inside the molecule might be looked on as exerting a certain pressure, the intensity of which was peculiar to the particular element under consideration. Thus, with iron the pressure had one value, and with copper another. If an atom of the one were put close to an atom of the other, the fact that the internal corpuscular pressure was different in the two atoms would tend to make corpuscles pass from one to the other.

What was it prevented this flow of electricity? A transfer would mean that the one atom would be left positively changed, and the other acquire a negative charge, so that the two would be equivalent to the two coatings of a Leyden jar. Now, when a Leyden jar was charged with a definite quantity of electricity, the larger the jar the smaller was the work required to charge it, this work being, in fact, inversely proportional to the capacity of the jar. Hence, the resistance offered to the transfer of a charge from one system of molecules to another would diminish if the size of either of the systems involved was increased. A collection or cluster, consisting of a large number of molecules, would thus correspond to a large jar, and to charge it up with a definite quantity of electricity would need a smaller expenditure of energy than would be required by the smaller jar represented by single molecules. Hence, it should be easier to get the electricities separated when dealing with clusters, or aggregates of molecules, than when dealing with two individual molecules, and when molecules were closely associated together, as in liquids and solids, than when independent, as in the case of gases.

It was not to be supposed that every molecule of a cluster lost a charge, but merely that the transfer of a single charge took place more easily when a considerable number were aggregated into a cluster. In other words, it was more difficult for atoms of iron and copper to become charged up when brought into contact than for plates of the two metals to do so.

When two dissimilar bodies were brought into contact, there was thus a tendency to produce electric separation, one side becoming positive and the other negative, and this tendency was the basis of the process of producing electricity by friction, the work expended in the friction providing the energy necessary to complete the separation by tearing the charges apart.

A remarkable phenomenon had been discovered by Quincke, who had found that small particles of solids floating in water or other liquids were set in motion by an electric field, sometimes in one direction and sometimes in the other, depending upon the nature of the particles, and on that of the liquid in which they were suspended. For example, particles of sulphur suspended in turpentine contained in a horizontal tube could be driven from one end of the tube to the other by coupling up the ends of the tube to a Wimshurst machine. On reversing the polarity of the ends the particles previously crowded into one end were rapidly cleared out and driven to the other end, and similar phenomena could be shown with particles suspended in water.

Consider, Sir Joseph said, such a particle in suspension carrying, say, a negative charge distributed over its surface. Then, on the adjacent water there would be a layer of positive electricity equal in quantity, and if any external force acted, it would push the positive as much as it pulled the negative layer. Hence, if the charges were rigidly connected together, there would be no effect. Yet, as a matter of fact, in most cases the particles did move through the liquid, and this was supposed to be effected by the outer layer of electrification slipping past the particle, and being made good or renewed by a fresh charge induced on the water molecules, which replaced those left behind by the motion of the particle.

If this were really the nature of the action at issue, it would seem as if there should be some limit to the

* Reproduced from *Engineering*.

conditions in which it might occur. His own view was that if the potential difference between the two coatings was sufficiently great, no motion would occur, and, of course, there would also be no movement if this potention difference was zero. It was, indeed, a suspicious fact that measurement made of the speed of these particles (which was proportional to the potential difference) showed that the speed did not depend on the size of the particles, but only on the potential difference, and the numbers deduced for this were all about 0.08 volt; the highest of which he could find a record being 0.05 volt in the case of copper particles in contact with water. This scale of values was just in the region of the energy possessed by the particles in virtue of their thermal agitation, that of the particles of air being 1/30 volt when measured on this scale. It was, he thought, very suggestive that the numbers found were all in this neighborhood, and it might be that the separation of the charges which permitted the motion, had to be brought about by the energy which the molecule possessed in virtue of its thermal agitation. Hence, if the energy required to separate the two coatings were very large compared with the kinetic energy of the particles, the two coatings would be held together, the particles would not move under the action of the electric field.

In the Cavendish Laboratory, Mr. McTaggart had experimented on the motion of electrified bubbles through a liquid, and, using centrifugal force to steady their motion, had observed their velocities with very great accuracy. An interesting point established was that the speed due to the electric field was the same whatever the gas in the bubble, whether oxygen, hydrogen, or air. Possibly this result was due to the difficulty of getting entirely rid of oxygen, very little of which might, perhaps, suffice to mask any specific velocity.

(To be concluded.)

Tide Analysis—A Simple and Inexpensive Apparatus*

By Ernest W. Brown, F.R.S.

THE object of this paper is the description of an apparatus for the analysis of tidal observations which anyone may quickly construct for himself at an expenditure of a dollar or so. Darwin's well-known apparatus[1] has disadvantages which he himself recognized. It consisted of strips of xylonite on which the observations were written, and of guide sheets carefully printed to show the positions in which the strips were to be placed for the evaluation of any particular tide. He had these made for a year's observations and about a dozen different periods; each sheet was to serve for seventy-four days and there were thus some sixty large sheets to be used.

The device described here is intended to obtain precisely the same result as that of Darwin. The strips are replaced by endless paper bands and the guide sheets by simple instructions for arranging the bands and for testing the correctness of the arrangements. The simplification is partly due to the introduction of adding machines, now in practically universal use where large masses of additions are to be performed. With them it is no longer necessary that the digits should be very accurately in column for easy addition; so long as the complete numbers are sufficiently nearly in a column as not to be confused with numbers in a neighboring column, the operator has no difficulty in following his work: with accurately ruled paper, however, the numbers can be put into accurately placed columns as easily as in Darwin's method. Nothing else in the device requires any great care. As its successful use depends mainly on small details, I have described the latter somewhat fully. There is also another reason for this. Experience has shown that a considerable proportion of the time of the operator is often taken up with the arrangement of his work, frequently more than the actual calculation. There is thus more opportunity for the saving of time and trouble and consequently expense (which is now the chief factor in reducing tidal observations) by the simplification of the arrangement of the work, than in any other part of it. An apparently trifling detail in operation may make the difference between success and failure in this respect.

The materials required are ruled paper, sheets of cardboard, paper cutter, a few brads and double-pointed tacks, and a board.

The ruled paper should be of good quality with smooth finish and not so heavy as to prevent it from folding easily. The horizontally and vertically ruled lines are to be uniformly a quarter of an inch apart. This size permits two figures to be written in each square with no parts of the figures projecting over the ruled lines.[2] Its width is to be 19 inches (72 squares + an inch overlap) and height at least 8 inches (32 squares).

The cardboard should be fairly flexible so that if bent into an arch whose height is about one sixth of the base, it will not tend to break and will return to its original form when released. The height of the card should be about 12 inches, its width rather less than 9 inches. The latter measurement is to be such that when two sheets of the ruled paper are folded closely over it one edge of the outer sheet shall come accurately over the ruled line on the sheet 18 inches from that edge.

A cover to the cardboard is made by folding a sheet of the same kind of paper (ruling is unnecessary) closely over it and pasting the edges together, care being taken that the cover does not stick to the cardboard. If the latter be bent a little the cover can easily be slipped off and on.

A convenient paper cutter is that used to trim photographs; it must be large enough to make a 9-inch cut.

Four brads are driven into a board so as to form a rectangle about 8 inches by 6 inches. They should be a little inclined inward along the direction of the 8-inch sides of the rectangle. The double-pointed tacks are partly driven in close to the brads with their lengths in the same direction, so that when the sheet of cardboard is bent and the edges placed between the pairs of brads it will remain bent and will be slightly raised above the board. Each brad and tack may be replaced by a small wood step nailed to the board.

In Darwin's scheme for the analysis of a year's observations, hourly heights are used. He also suggested that such units should be adopted (e. g., tenths of a foot or inches) that all heights could be expressed by two digits. It is convenient to describe the use of the apparatus on this basis, although there is room for four digits if necessary. The twenty-four observations for the first day (day 0) are written in every third square of the top line of the ruled paper beginning with the third square from the left and ending with the seventy-second. The second and succeeding days are similarly written in the following lines up to the end of the first block, which, for the solar tides, contains thirty days. At the end of several of the blocks one day of observations is not used for these tides: it must, however, be inserted. Thus, twelve sheets contain all the observations; these may be written in, as they are measured from the tide curve. They are then summed according to Darwin's published instructions, both horizontally and vertically, and the results used for the analysis of the solar and long-period tides.

For this and future arrangements, the number of the day is written in red ink twice on each line in any one of the unoccupied squares, once between the left edge and the observation for 11h and once between the observation for 11h and 23h. A pair of single red lines is ruled so as to inclose all the observations at 0h and a pair of double red lines to inclose all those at 12h.

The observations have now to be regrouped so as to give an analysis for mean lunar time. For this purpose the first sheet is placed face down on the table and the two edges folded over so that the left edge comes on to the ruled line following the observations at 23h. It is pasted in this position by using the inch overlap, care being taken that the inside portions of the paper do not stick together; the position of the folds is immaterial. The folded sheet is then placed on the paper cutter and each day of observations is cut off; it will form a closed band. The first thirty-seven of these bands are placed in order on the paper cover, previously made, by bending the cover in one hand and slipping the bands on with the other. The cover carrying the bands is then flattened out and the sheet of cardboard bent and slipped in. The remaining nine cards, each carrying thirty-seven days of observation, are treated in the same manner. Thus the whole year's observations are contained on bands stretched over ten cards.

The bands have now to be arranged in accordance with a scheme made out in advance. Suppose that the arrangement required is such that the observations at the following times are to be brought into the same column: 0d, 0h; 1d, 1h; 2d, 2h; 3d, 3h; 4d, 4h; 5d, 4h; and so on. The first card with cover and bands is bent and the edges placed between the brads on the board, care being taken that a band does not rest on the tacks. Any band is then easily movable around the card; it can be rapidly and certainly brought into any position by gently pressing on it with a piece of soft red rubber and sliding it to the right as required.[3] If the band be pinched over the edge of the card when it is brought into position it will remain there while the other bands are being placed. The card and cover being about 12 inches long and the sum of the widths of the thirty-seven bands being only 9.25 inches, there is ample room for the movement of the bands, it being not necessary that they should lie very close to one another.[4] The remaining nine cards being treated in the same way, the observations are ready for the summing which gives the M series of tides.

The other rearrangements follow a similar process; a separate set of instructions for the ordering of the bands is given to the operator for each arrangement. After the process is completed the cards are slipped out of the covers carrying the bands, and the latter can be stored away in an envelope on which it is only necessary to write the year and the port. The observations have thus only been written once and are always available for future reference.

If the observations be typed on to the sheets, the dimensions of the apparatus may be conveniently reduced in the ratio 3:2.

It remains to explain the instructions to be given to the operator. The single and double pairs of red lines and the number of the day are the guides; one pair and one day number will be found on each face of the card when the bands are placed over it. Define "no step" for any day as a case when the observation at 0h on its band is immediately under that for 0h on the band next above, and the "one step left" when that at 1h is immediately under that at 0h on the band next above. Similarly for "one step right." The words "left" and "right" need not be repeated since there are never both left and right steps with any one tide. The instructions to the operator consist only in giving to him the step for each day, and some other fact which will enable him to test his work. The method of obtaining the instructions and the test will be explained by giving in detail those for what Darwin calls "mean lunar time."

The speed of this time in degrees per mean solar hour is 14.4920521 degrees. It therefore moves 347.80925 degrees in twenty-four hours. This, on division by 15, shows that 23.187283 mean lunar hours are equivalent to 24 mean solar hours. As we can only use observations at exact solar hours, the position of the band on day n is obtained by finding the nearest integer to

$$(n + \tfrac{1}{2})\ 23.187283,$$

the approximate coincidence being made in the middle (12h) of each day of observation. Thus, for days 1, 2, 3, 4 the red lines must be one step left of those on the previous days, respectively, for day 5 no step, for days 6, 7, 8, 9, 10 one step left, for day 11 no step, and so on. The whose series is obtained by converting 0.187283 into a continued fraction. The successive convergents are

$$\frac{1}{5}\ ,\ \frac{2}{11}\ ,\ \frac{3}{16}\ ,\ \frac{53}{283}\ ,\ \frac{162}{865}\ ,\ \ldots$$

The third convergent shows that the successive 6th, 5th, 5th days are to be no-step days, while the fourth convergent shows that for 283 days there must be eighteen cases in which the no-step day is the 6th and thirty-five cases in which it is the 5th ($18 + 35 = 53$, $18 \times 6 + 35 \times 5 = 283$). We have thus the series 6, 5, 5, repeated seventeen times, then 6, 5, and finally 6, 5, 5, to the end. The above examination of the first eleven days shows that the first no-step day is day 5, the next day 11, which facts give the start of the 6, 5, 5 series. It is easy to run through and find the days on which 0h comes into the first column. Thus the instructions to the operator are as follows:

"Place each band one step to the left of the previous band except on the following days when no step is to be made: 5, 11, 16, 21, and thereafter the 6th, 5th, 5th in succession until the no-step day 277 is reached. The days 283, 288, 294, 299, 304 are no-step days and thereafter the 6th, 5th, 5th in succession until the end. For testing the arrangement, note that the observations at 0h for the following days are in the same column: 0, 29, 58, 59, 88, 118, 147, 177, 206, 236, 263, 295, 324, 354."

Similar instructions may be made out for the other periods.

This apparatus is more convenient for tidal analysis than that which I described[5] some years ago and which has been continuously in use for the synthesis of the small terms in the moon's motion which are to be inserted in the lunar tables. It is not, however, applicable, like the earlier device, to general harmonic analysis.

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* From the *American Journal of Science.*

[1] *Roy. Soc. Proc.*, A, vol. lii, p. 345, 1892, Sc. Papers, vol. i, 216.

[2] I have found two figures between ruled lines a better guide to the eye than one figure between closer rulings, especially when dealing with numbers of several digits.

[3] If slid to the left there may be trouble owing to the inside pasted edges of the band catching on the edge of the cover.

[4] If the cover be made of fairly stiff paper, the cards and the board may be dispensed with and the bands moved by one hand while the other holds the cover. But this method is not quite so convenient for use.

[5] Monthly Notices R. A. S., vol. lxxii, pp. 454-463.

Making Museums Useful

What an Active Curator Can do for a Small Collection

By Harlan I. Smith, Geological Survey, Ottawa

For many years we have all heard an almost constant complaint from museum curators and others interested in museums, that there was not sufficient money available for the purchase of specimens, the erection of the desired building, and the building of cases. It is true this complaint was not always, though often, made as a sort of apology for the lack of arrangement and labelling, the presence of dirt, and the failure of the museum to be very useful to the community, or even interesting to the average visitor. Some museums spend thousands of dollars for specimens annually for many years in succession, while their exhibition halls lack sufficient labels of all kinds, and especially the general divisional labels and case labels which are among the first needed to make a museum useful to the public. It were better to buy a 5 cent book to read. After all, a museum may better do without many specimens than to be lacking in the most essential labels. One specimen such as a diamond or elephant may not only cost more than thousands of equally instructive specimens, such as a piece of coal or a kernel of corn, but will use up more of a museum's funds than would be needed to completely label a large part of a great museum or an entire small one. So many institutions waste so much time in discussing what color, and weight of cardboard or other material will be used for labels, that many years pass before any exhibit is adequately labelled, whereas it would be better to label it with written or typewritten labels on any kind of paper, so that the present generation may get useful services from the exhibit, and to replace these tentative labels whenever a better kind has been found. In this way contemporaneous generations may derive benefit from the museum, which under the usual existing method is lost to them through providing for future generations. Personally, I doubt if those who follow these methods will deliver the benefits promised.

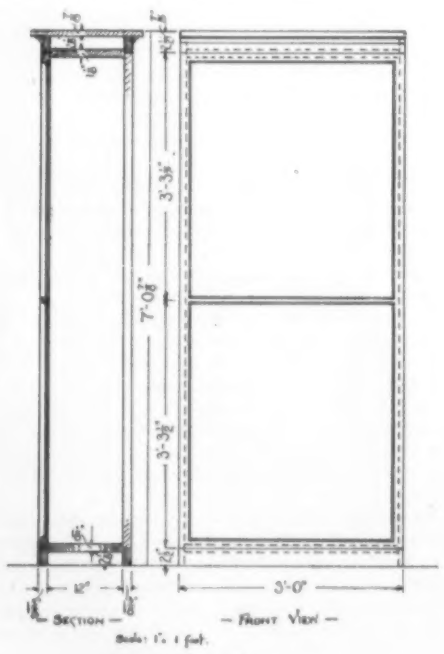
Waiting for a fire-proof or permanent or larger building is certainly a waste of time. I once knew of a professor who complained that he could not teach a number of interested students because he had no class room, but I believe I can recall hearing of certain great teachers of antiquity, who taught their disciples by the roadside, without either class room or place to lay their heads, and this idea also applies to museums, for after all, the whole outdoors is the best museum. A corner in every school-house may be a museum; a nook in every board of trade building may serve the same purpose; even the Sunday school room may have its little museum. Much may be learned in both churches and saloons. A cheap inflammable building may be a more useful museum building than a fire-proof structure costing millions. In an inflammable building it would not be wise to store valuable material, but in it could be displayed labels, pictures, maps and books illustrated by such cheap and common specimens as elm leaves, squash seeds, broken pebbles, English sparrows, mice, and the skull of a dog. A museum of such specimens accompanied by appropriate labels, books, maps, pictures and models, might easily be of more service to a community than some existing museums costing say ten times as much.

Cases in which to put specimens delay curators not months but years. First there is the discussion as to what kind of a case and how to make it dust proof; what the material, and the color of the background. In this way, while waiting for cases, years go by. People who would use the museum grow old and die. Children who have time in their receptive condition of mind to profit most in the museum grow up and have their time otherwise occupied. As a matter of fact, all these people could have gotten the maximum amount of benefit from the museum, had the specimens been exhibited without any case at all, on the wall, on tables, on the floor, or even out in the big out-door world, had there been sufficient and appropriate labelling.

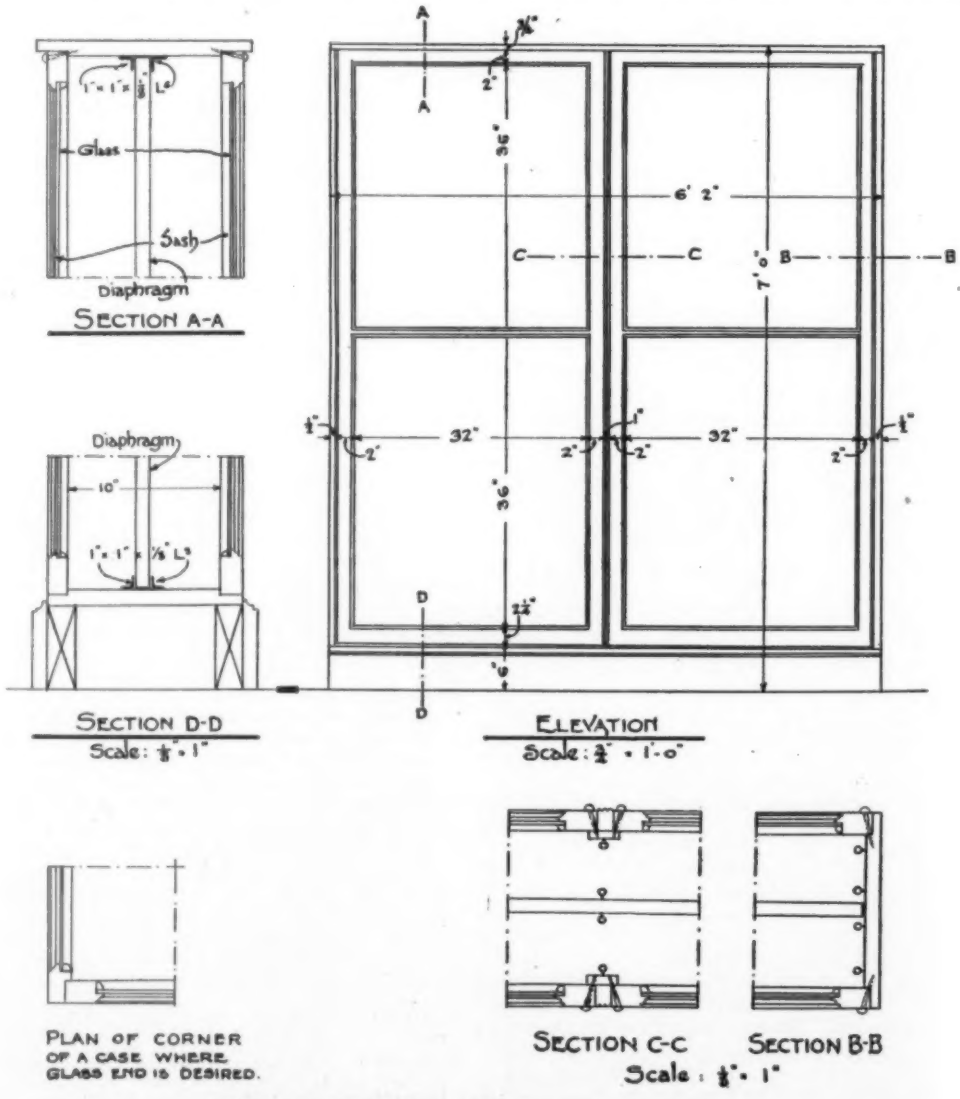
No doubt the background should be carefully considered, and that certain colors are better than others. Perhaps the relationship of colors or general harmony and the relationship of light and a subdued quietness of color are of extreme importance, but visitors in a museum where the cases were entirely white have been interested and obtained useful information some time before noticing whether the cases were white or black.

The museum of the Natural History Society of New Brunswick, located at St. John, has a comparatively small amount of money to spend each year, and its curator has not had the great amount of university education and travel enjoyed by some curators of larger and richer museums. In this his museum is perhaps fortunate, for in so far as his funds permit he is actually putting in force some of the most up-to-date museum methods. He has insufficient help, a comparatively poor building and miserable cases, yet he carries on field research, conducts a lecture course for adults and one for school children, giving two lectures per week during the school season, takes out large parties of young people to investigate and study in the field, issues some publications, identifies material collected by school children and sent to him by their teachers, and provides the teachers of the schools with nature study leaflets suggested by the objects sent within 24 hours of their receipt.

Every fall when the Canadian Pacific Railway supplies two cars filled with exhibits under the auspices of the provincial government of New Brunswick, to be drawn over its lines and side tracked for a few hours at each station where an audience may be had, this live curator accompanies the train. One of the cars usually contains exhibits of pigs, chickens and other live stock; the other exhibits relating to agriculture, such as bees, nursery trees, cream separators, and whatever the Government experts consider may uplift the agriculture of the province. Our curator friend installs material from his museum, supplemented by specimens collected for the purpose. These specimens show such things as birds which benefit the farmer's crops, insects which damage them, and drawings which he hastily makes with cheap materials, but which may be fastened up around the walls of the car or held up while he lectures to the rural audiences on things which will make their work more successful not only to themselves but to their province, and which will make their lives more interesting and pleasant while they are at work. No cold blooded corporation like the Canadian Pacific Railway would furnish a two-car train, man it and haul it for about a month each year, did they not believe it would make the people who visit it more prosperous, so that they might spend more money in shipping freight and traveling on the railroad. He has had an ordinary carpenter remodel some of the antiquated cases, cutting off the ginger bread and reducing the amount of frame in proportion to the amount of glass, and as fast as his funds permit, he is carrying out this scheme throughout the museum. But more interesting to us in the present connection is the cheapness of the cases which he has had built as a beginning towards those which he in-



Plans for a cheap case.



Working drawings of a more elaborate and expensive case.

tends to have throughout the museum for the housing of instructive and useful exhibits, his idea being that while these cases are not all he would desire, still they serve the purpose so that the public, both old and young, both scientist and layman, may derive benefits from the museum until such time as he has secured funds for ideal cases.

With this inspiration and having in the Rocky Mountains Museum need to build at least one case and install it within three weeks, I designed a cheap case for a small museum or a museum having small funds.

Any ordinary house carpenter can make such a case at an extremely low cost. The materials may be obtained wherever window sashes are to be had. All the woodwork may be cut to sizes at the local mill, and this is especially desirable where a large number of cases are to be made, as it will save much of the expense of the carpenter work.

The kind of wood and molding may be varied according to what is cheapest and most easily obtainable, care being taken, however, if any molding is, used to choose that which is simple, dignified and will not gather dust. It may be desirable to let the size of the glass panels and even of the case depend somewhat on the size of glass that can be obtained.

The advocating of a cheap case, its manufacture, installation and use, in no way militates against advocating the best and most expensive cases on the market, but on the contrary paves the way for them. The museum that waits to be useful until it can have cases costing many hundreds of dollars each will probably wait a long time for financial support. The museum that teaches and otherwise becomes useful to the public with clean, neat, though cheap cases, will gain the sound financial support which it deserves, at least as soon as the present generation of children grow to positions of authority.

One form and size of this case is practically a simple box 5 feet wide over all, with a window sash screwed on as a cover. The sides of the case may be 7/8 stuff, 1 foot wide and 7 feet high. The top and bottom of the same stuff 1 foot wide is set in about 3 inches more or less from the ends of the sides. These four boards constitute the box frame without front or back. A piece 2½ inches wide is nailed across from side to side at the top and bottom of both front and back to strengthen the frame and to cover the space above and below the top and bottom of the case; the lower one also serves as a support upon which the lower edge of the glass front and glass or wooden back frames may rest. This 2½ inch strip only partly covers the edge of the top and bottom, so that the screws holding the front and back may be screwed into the top and bottom, but also so that there may be no crack or space left at the outside of the top and bottom of the case. A kicking molding may then be put across at the bottom, both front and back, but it should not project beyond the ends of the case, as this would prevent several cases being placed (close together) end to end. In short, the ends of the case should be flush. A board is next put over the top of the case to keep dust and rubbish from gathering in the space outside of the case top, and to give the case finish. This board should project an inch or two in front and behind, but as in the case of the kickboard should not extend beyond the ends of the case. A molding may be placed below this top in the corner between it and the 2½ inch strip across the top of the front of the case according to taste. The general label may then be fastened on this molding, on the 2½ inch strip, or from the cover of the case to the 2½ inch strip. In fact one purpose for having the case extend above the top of the exhibition space, that is above the top of the glass sash, is to provide this space for a case label. On the other hand a case label may be painted directly on the 2½ inch strip or the sash.

The front of the case is made of a simple window sash, such as may be obtained in any town where a sash and door factory exists, or for that matter where houses are built. It is fastened with round headed screws engaging the edge of the sides and top of the case, the frame resting upon the 2½ inch strip across the lower part of the case. By screwing the frame on, it is not necessary to go to the expense of hinges and locks. The screw holes may be soaped, waxed, or metal screw sockets may be used if it seems desirable to go to that expense. A screwdriver serves as a key. Moreover, by drawing the screws tight, the case may be made as near dust-proof as is necessary in a small museum. In fact much more fuss is made about dust-proof cases and about getting fine cases than about using them after they are obtained. A little attention given to wiping out cases, cleaning specimens and looking to the upkeep of the specimens in most cases would be cheaper and quicker than giving so much attention to dust and insect proof cases. Moreover, going over the specimens say once a year for such a purpose, the curator could hardly fail to note the lack of order and labels, and many things, which he could then do to improve the usefulness of his exhibit. However, cotton tape or wicking set in a plained groove may be added to exclude dust if desired.

The glass should be in the largest pieces obtainable, up to the full size of the frame, and where more than one piece of glass is required preference should be given to running the mullions horizontally so that they may the more often fall opposite a horizontal shelf edge instead of vertically across the line of vision. It is hardly necessary to say that the glass should be of the best quality which the museum can afford, and certainly should be free from blobs and other blemishes. If it is sufficiently heavy, there will be no need of disfiguring signs requesting visitors not to lean on the glass.

Shelves may be cut about 1/8 of an inch shorter so that they may be moved easily and may rest upon round headed screws or still better on screw eyes turned horizontally, one at each corner of the shelf. When it is necessary to raise or lower the shelf these screws are easily changed and the holes may be puttied up and touched with color, although if left they will no more disfigure the case than the ordinary ratchets used for holding shelves at various heights. The case may be stained or painted with a dull finish, certainly not a very glossy varnish, perhaps preferably with a thin wash, to give it a somewhat neutral color in harmony with that of the walls of the building in which it is to stand.

The back of the case should certainly be put on in the same way as the front, so that if it is ever desirable to turn the case at right angles and have glass upon both front and back, the back may be removed and a glass frame may be put on. If the back is to be solid woodwork which is perhaps desirable where heavy things are to be hung from it, care should be taken that it is built so that the expansion and contraction due to changes in the weather or the heating of the building may not strain the rest of the case. Perhaps as good a way as any would be to let the back of the case be a frame with compo board, as the compo board could be replaced at any time glass was desired. A diaphragm set back against the rear frame would serve for heavy objects and could be covered with burlap or print paper, as desired.

When the case has glass front and back, that is when the exhibit is to be viewed from two sides, or when it is not desirable to use the full depth of the case for the exhibition on hand, a diaphragm about 1/8 of an inch shorter and narrower than the inside of the case may be inserted at any distance from the front of the case, and held in place either with round headed screws through the sides of the case or with small angle irons in front and behind the diaphragm. This method of fastening the diaphragm allows it to be adjusted or removed in a very few minutes with practically no waste and no unsightly scars which could not be retouched with putty and colored.

The cases should be made in uniform sizes or multiple sizes, like sectional book cases, so that they may be moved about and re-assembled, for instance by placing two 3 foot cases side by side to harmonize with a 6 foot case, and so on, or by placing two cases 6 inches deep back to back to approximately harmonize with a case 1 foot deep. Cases should never be fastened to the walls in such a way that when they are moved the room is disfigured, requiring re-plastering or re-painting. A little forethought along these lines will save a large portion of the funds of museums which might be used for other purposes instead of being thrown on the junk heap.

If it is desirable to let light in one or both ends of the case they may be made like the front and back, but then care must be taken that the frame is large enough to hold the screws necessary for supporting any shelves used. If a diaphragm is used, the screws to hold the rear corners of the shelves may be inserted in the diaphragm.

These general plans may be varied, the cases may be made of various heights, widths, and depths. They may be built with higher or lower bases and tops; or again, shorter cases may be built and placed upon tables or pedestals; cases may be super-imposed or hung upon a wall. Very large cases might be made on this same principal, by substituting frames with glass in place of the wooden sides of the cases, it being only necessary in such cases to carry the sides up and down from the top and bottom of the frame in the same manner that the front and back is carried up and down. If the case is so large, as for habitat groups, that it is necessary to have more than one frame, a mullion to which to screw the frames may be inserted between the top and bottom of the case where necessary, but this should not project beyond the sides of the frame. By this means the amount of wood exposed to view is kept at a minimum. If desired, a molding can be screwed over the crack where the frames meet, and if fastened to one of the frames that frame may be taken off first in opening and closing the case, which will save the trouble of unscrewing the molding.

One of the simple forms of these cases, 5 feet wide by 1 foot by 7 feet was made, with the exception of the frame and glass, by two carpenters, during the time which they could take from other work in a single day while assisting in reorganizing the Rocky Mountains Park Museum.

The specifications which have been made by Mr. P. A. Taverner to accompany this description are for a somewhat more complicated and slightly more expensive case, and consequently a number of the dimensions and methods of construction are slightly different.

MATERIAL.

Lumber—All material in case to be of clear, white pine, whitewood or other material most readily obtainable in locality in clear lengths free from large or unsound knots or shakes.

All exposed work may be in oak or other wood to match fittings already installed.

Sash—To be 1 3/8 inch thick of common stock pattern—rails and styles 2 inches wide from glass to jamb, and of sizes as shown.

Tops and Ends—May be of 7/8 stuff with 3/8 by 1 3/8 inch rebate along sash jamb or may be built up of two thicknesses of ½ inch stuff. The inner lining being of matched stuff well cramped together and blind nailed.

Diaphragm (to be supplied only where desired)—To be of 7/8 inch stuff fastened together with flush end styles well nailed to prevent warping. All should be covered, both sides with burlap or other covering material or paneled according to decoration or other scheme of museum. Diaphragm to be held upright and in place by 1 inch by 1 inch by 1/8 inch iron angles screwed to top and bottom of case on either side of diaphragm. For 3-foot cases there should be two pair of such angles, top and bottom, and for 6-foot cases there should be three such pairs. Diaphragms may be moved to any situation in case by changing position of angles.

Shelves—Shelves for light specimens may be supported by screw eyes inserted in ends and diaphragm or mullions as indicated on drawings, turning them flatways and allowing them to project enough to engage shelves. For heavy specimens, iron brackets—stock sizes, or Shrosbree specimen hangers may be used whenever needed. If a coarse burlap is used over diaphragm, screws may be put in and removed as many times as necessary without causing disfiguring scars on the surface.

Base or Mopboard—To be stock 6 inch base of whatever design may be desired and may be readily obtained at local lumber yard or mill.

Ends—All ends of cases to present perfectly flush surface, so that two or more cases may be butted together to appear as one case without unsightly or dust-catching spaces between.

Cases may be made in units of either 1 or 2 sash. A 1 sash case will then be just half the length of the 2 sash cases and will line up with them in series. The sashes are to be fastened in place by 2½ inch brass, round headed screws, driven through the sash into the frame behind. With this method neither locks or hinges are necessary, and all can be constructed by an ordinary carpenter without special joinery skill.

Glass—To be of sizes shown and of as good quality as procurable. The principal faults to be looked for being color, waves, bubbles or flaws.

Scientific Exploration in Central Asia

FROM Dr. F. de Filippi the Royal Geographical Society has received a report on the journey of scientific exploration which he has been carrying out between India and Central Asia, under the joint auspicies of the Italian and Indian governments. The expedition has lasted sixteen and a half months, and in that time has accomplished work of the highest scientific importance in Northern Kashmir and Southern Turkestan. The numerous staff included eminent Italian men of science, as well as a party from the Survey of India.

From the point of view of geographical discovery the most interesting result has been the exploration of the eastern section of the giant Karakoram range. Here was found a glacier—named Remo—of unexpected size and importance. It is composed of three large rivers of ice, each about 20 miles in length and from 3 to 5 miles in width, and has an area estimated at over 300 square miles.

The expedition derives its chief importance, however, from the systematic scientific observations which were taken at a series of fourteen stations established between Srinagar and Kashgar. By means of these observations the gravimetric survey made by the Indian Survey Department in the plains of Hindustan has been joined on to the similar Russian survey in Russian Central Asia, and the whole has been connected with the gravimetric survey of Europe.

Regular meteorological and magnetic observations were also taken at the different stations. By arrangement with the Indian Meteorological Department, pilot balloons were sent up simultaneously from the expedition's stations and from a number of the department's permanent stations; and by a comparison of the results it is hoped to obtain valuable information respecting the monsoon winds.—*The London Daily Telegraph.*

The History of Opium*

Facts Concerning One of Our Most Valuable Drugs and its Derivatives

By David I. Macht, A.B., M.D.,[1] Johns Hopkins University

If the entire materia medica at our disposal were limited to the choice and use of only one drug, I am sure that a great many, if not the majority, of us would choose opium, and I am convinced that if we were to select, say half a dozen of the most important drugs in the Pharmacopeia, we should all place opium in the first rank. If we were to inquire, however, into how much the great majority of the medical men know about the history of this wonderful product of plant life, which, when judiciously employed, has proved such a boon to suffering humanity, if we were to ask about the origin of some of our most familiar remedies—laudanum or paregoric, for instance—I fear the information gleaned would be meager. It is doubtful whether it is even generally known that opium, so widely used in China, is not indigenous to that country, but was introduced there at a comparatively late date. This were apology enough for a brief historical sketch on the subject, but a glance at the history of opium and its derivatives from the earliest time to the present may teach us more. If the aim of the history of medicine is not altogether the recitation of interesting anecdotes, but rather to trace the progressive development of our noble art and science, then is the history of no other drug more calculated and better fitted to illustrate the gradual transition from the obscurity and mysticism of the ancient *Dreck-Apotheke* or polypharmacy and kakopharmacy to the rational therapeutics of the present day.[2]

EARLY HISTORY.

The medicinal properties of poppy juice date from a remote period, and yet not so far back in antiquity as we might expect, for the earliest definite and authentic references to it are found only in the Greek and Latin literatures. Of course, recalling the mystic rites and highly developed culture of the ancient Egyptians one is inclined to imagine that the narcotic properties of opium were known to them; but the investigations of Unger (1857) have failed to trace any acquaintance with opium in Ancient Egypt, and Dr. Ember, of the Semitic Department of this university, tells me he knows of no reference to it in Egyptian literature. According to some Hebrew scholars, there is a reference to poppy juice in the Bible. In several passages in the Old Testament the word *rôsh* is mentioned in connection with the word *la'anah*, wormwood or absinthe (Jer. viii 14, ix 14, etc.). *Rôsh* in these passages is in the authorized version rendered hemlock. *Rôsh*, however, in Hebrew is the word for "head," and so it has been taken by later scholars to mean poppy-head, and *me-rôsh*, or the juice of *rôsh*, rendered by Jewish interpreters as "poison water," is taken to mean the juice of the poppy. This interpretation fits well enough in the context, and further support is given it by the fact that the Latin for poppy-heads is *caputa*. Prof. Haupt is convinced that *rôsh* means the poppy, and so also is Prof. Post, who is considered an authority on the flora of Palestine. In the Talmud we have one reference to opium, under the name *ophion* (Jerusalemic Talmud, Tr. Abodah Zarah, 40a), but that word was clearly borrowed from Greek.

In regard to Sanskrit, Prof. M. Bloomfield of the Sanskrit department of this university tells me that opium is not at home in India, and so in the classical Hindoo literature (Brahmanical, Buddhist, Jinist) there is found no reference to it. From the time of the Mogul Conquest on there appears a word *Khash-khash* which means poppy-seed, and *Khash-khash-rasa*, juice of the poppy. In this it is easy to recognize our modern wood *hashish;* and so it seems that at that early date the narcotics opium and cannabis indica were confused with each other.

In modern Sanskrit lexicons there are found the names *aphena* and *ahi-phena* applied to opium; *aphena* strictly means "foam," and *ahi-phena*, "serpent's foam." As these words for opium do not occur in any literary document, Dr. Bloomfield suspects that they are the English opium "sophisticated by what is known as popular etymology."

The original home of the poppy was in Asia Minor. From there it was carried to Greece at a later period.

The name opium is derived from the Greek ὀπός or "juice." From this word were later formed the Hebrew *ophion* already mentioned, and more particularly the Arabic *af-yun*, which has found its way into other Asiatic languages. The Chinese name for the drug *o-fu-yung* (and its modifications *ya-pien* and *opien*) are not of native origin, but are all derived from the Arabic.

It is not at all certain whether Hippocrates was acquainted with the juice of the poppy. According to Wootton, he refers to a substance called *mecon*, to which he attributes a purgative as well as narcotic action. Some think that it was opium; others believe that he was referring to another plant. In any case, he made but very little use of the drug.

The first authentic reference to the milky juice of the poppy we find by Theophrastus at the beginning of the third century B. C., when he speaks of it as μηκώνιον (meconion).

Scribonius Largus,[3] in his "Compositiones Medicamentorum," about the year 40 of the present era, describes the method of procuring opium from the capsules of the poppy, and about the year 77 of the same century Dioscorides makes a distinction between the juice of the capsules which he called ὀπός and the extract of the whole plant or μηκώνιον, which he regarded as less active. He describes the method of incising the capsules, and refers to adulterations of the drug with the milky juices of other plants, such as Lactuca, so that from his statements it is evident that the collection of opium was quite an industry in Asia Minor at that time. He also describes the preparation of a syrup of poppies or *dia-kodion*, which is the original of the syrup of poppies of the German and other Pharmacopeias to this day.

Pliny devotes some space to a description of opium and its medicinal use, and the drug is mentioned repeatedly as *lacrima papaveris* by Celsus in the first century and by numerous other Latin writers. Galen spoke enthusiastically of the virtues of opium confections, and the drug was soon so popular in Rome that it fell into the hands of shopkeepers and itinerant quacks.

The introduction of the drug to the natives of the East was through the Arabs, and in the first instance to Persia. Its introduction into India seems to have been connected with the spread of Mohammedanism and was favored by the Mohammedan prohibition of wine.

The Arabic physicians used opium very extensively, and even wrote special treatises on some of its preparations. The most celebrated of them, Abu-l-ali-ibn-Sina, more commonly known as Avicenna (980-1037), recommended it especially in diarrhea and diseases of the eye. Avicenna himself is said to have met death from an overdose of the drug. Serapio (about 1090) used it freely, and Maimonides and Averroes each wrote a treatise concerning the theriaca, of which I shall have much more to say a little later.

The earliest mention of opium as a product of India is by the traveler Barbosa, in his description of the Malabar coast in 1511. A Portuguese historian, Pyres, in a letter to Manual, King of Portugal, in 1516, speaks of the opium of Egypt and Bengal. It is from Egyptian Thebes that we have the terms "opium thebaicum" and the alkaloid thebain.

Opium is supposed to have been brought to China first by the Arabs, who are known to have traded with the southern parts of the empire as early as the ninth century. Later the Chinese began to import the drug in their junks from India. At that time it was used by them exclusively as a remedy for dysentery. It was not before the second half of the eighteenth century that the importation of opium began to increase rapidly through the hands of the Portuguese, and a little later through the famous East India Company. In 1870 the English established an opium depot in Lark's Bay, south of Macao, and the traffic rapidly increased, so that very soon the Chinese authorities began to complain, and in 1820 an edict was issued forbidding any vessel having opium on board to enter the Canton River. A system of contraband followed, then political friction between England and China, and the so-called Opium War, which culminated in the Treaty of Nanking (1842) by which five ports of China were opened to foreign trade, and in 1858 opium was admitted as a legal article of commerce. By that time the vice of opium-smoking had spread like a plague over the gigantic empire, and became so deeply rooted that, in spite of innumerable edicts and decrees, all efforts to check its growth have been powerless. A poor sort of missionary work by the enlightened West among the heathen Orientals!

I shall not spend here any more time in tracing the history of opium in China, or in dwelling on the horrors of the opium habit, with its frightful constipation and even more terrible diarrhea, and the physical and mental degeneracy to which it leads. Our object is rather to follow the use of opiates therapeutically, and in Europe.

Since the time of Galen, the use of opium was continued in a disguised form in various concoctions and confections containing so many ingredients that the distinction between the important and useless could not be discovered, and the value of the drug was overlooked, except by a few brighter minds.

The famous physician of the middle ages, Philippus Aureolus Theophrastus Bombast von Hohenheim, commonly known as Paracelsus (1490-1540), owed much of his success to the bold way in which he administered opium to his patients. He is said to have carried opium in the pommel of his saddle and called it the "stone of immortality." His followers were as enthusiastic as himself over the virtue of opium. Platerus of Basle in 1600 strongly recommended it, and Sylvius de la Boe, a famous Dutch physician, declared that without opium he could not practice. The celebrated chemist and physician Van Helmont, about 1640, used it so frequently that he was called Doctor Opiatus, and Sydenham about 1680 writes that "among the remedies which it has pleased Almighty God to give to man to relieve his sufferings, none is so universal and so efficacious as opium."

THE FOUR OFFICINAL CAPITALS.

No better illustration of the widely beneficent properties of opium and at the same time of the hopeless muddle of superstition, kakopharmacy and polypharmacy pervading the older materia medica and therapeutics, can be given than by a brief description of the four remedies which are sometimes known as the four officinal capitals, of which Wootton,[4] in his "Chronicles of Pharmacy, says, "There were writers who ventured to criticize some of the details of composition, or some of the uses made of these compounds, but the possibility of medicine existing without them was hardly contemplated previous to the eighteenth century." These four standbys or panaceas were the *mithridatium*, *theriaca*, *philonium*, and *diascordium*.

Mithridatium was a confection which derived its name from Mithridates VI or the Great, king of Pontus in Asia Minor, born about the year 134 B. C., who was one of the most troublesome foes the Roman Republic had to deal with. He was finally defeated by Pompey. This personage is said to have been a student of poisons, and was accredited with having invented or concocted an alexipharmac or antidote as a protection against them, which was named mithridatium after him. The legend goes to say that when conquered by the Romans, to escape capture he poisoned his wife and daughters and then took poison himself; but according to the story he had so successfully immunized his body to all sorts of poisons that his efforts at suicide proved unsuccessful and he had to call on one of his soldiers to dispatch him. Hence, the origin of the term "mithridatism" or immunization against the effects of a poison through gradual administration of small doses of it. As the king of Pontus was accredited with having possessed especial skill in the production of medicines, his conqueror, Pompey, took care to ransack his medical writings and secure whatever he could. Thus, whether from Mithridates or not, a panacea bearing his name found its way into Roman literature and became very popular. Various modifications of it were later made, the most important of which was the so-called theriaca.

Theriaca was invented by Andromachus, the physician of Emperor Nero, and was devised as an improvement on mithridatium, which until then was the great antidote of Roman pharmacy. The most important difference between the two was the addition of vipers. The word "theriaca" comes from the Greek θηρίον, wild beast, of serpent, and has reference to its use as an

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* From the *Journal of the American Medical Association.*

[1] This sketch is intended to be an introduction to a pharmacologic study of some opium alkaloids carried on by the author and endorsed by a grant from the Council on Pharmacy of the American Medical Association.

[2] In the preparation of this manuscript the following authorities have been frequently consulted: Geissler and Möller: Real Encyclopedie der Gesammten Pharmacie, Leipzig, 1886-1891. Flückiger and Hanbury: Pharmacographia or History of Drugs, 1874. Rice: New Remedies, 1876, p. 229. Jones, John: The Mysteries of Opium Revealed, London, 1701. Guareschi: Einführung in das Studium der Alkoloide, Berlin, 1896. Thompson, C. J. S.: The Mystery and Romance of Alchemy and Pharmacy, 1892. Jeffreys and Maxwell: Diseases of China, 1906.

[3] Largus, Scribonius: De Composition Medicamentorum, 1786.

[4] Wootton: Chronicles of Pharmacy, 1910.

antidote against snake bites. According to Galen, the virtues of this panacea were the following:

"It resists poison and venomous bites, cures inveterate headache, vertigo, deafness, epilepsy, apoplexy, dimness of sight, loss of voice, asthma, coughs of all kinds, spitting of blood, tightness of breath, colic, the iliac poison, jaundice, hardness of the spleen, stone, urinary complaints, fevers, dropsies, leprosies, the troubles to which women are subject, melancholy, and all pestilences."

Though all this may seem a huge joke, all these virtues were accepted down to the seventeenth century, and many learned treatises were written on the subject. For some centuries various cities, such as Constantinople, Cairo, Genoa, and Venice, gained the enviable reputation of manufacturing the most efficient theriaca. Later Venice overshadowed them all; and the Venice theriaca, or as the word became corrupted, Venice *treacle*, was for a long time famous, and is found in the London Pharmacopeia as late as 1745. Our present word "treacle" is derived from this confection; in earlier English works, however, treacle signified much more than molasses, and was used metaphorically for the divinest blessings.

I am now going to quote the ingredients of theriaca, as given by Galen, first to illustrate the curious conglomeration of an enormous number of useless drugs, and secondly to point to the presence in it of opium, to which probably a great part of its virtues was due. The ingredients of this, as well as of mithridatium, were given in Greek verse, in order that they might be better remembered.

ELECTUARIUM THERIACALE MAGNUM.

"Root of Florentine iris, licorice, 12 ounces each; of Arabian costus, Pontic rhubarb, cinquefoil, 6 ounces each; of Ligusticum meum, rhubarb, gentian, 4 ounces each; of birthwort, 2 ounces; herb of scordium, 12 ounces; of lemon grass, horehound, dittany of Crete, calamint, 6 ounces each; of pennyroyal, ground pine, germander, 4 ounces each; leaves of laurus cassia, 4 ounces; flowers of red roses, 12 ounces; of lavender, 6 ounces; of St. John's wort, 4 ounces; of lesser centaury, 2 ounces; saffron, 2 ounces; fruit of amyris opobalsamum, 4 ounces; cinnamon, 12 ounces; cassia lignea and spikenard, 6 ounces each; Celtic nard, 4 ounces; long pepper, 24 ounces; black pepper and ginger, 6 ounces; each; cardamoms, 4 ounces; rape seeds, agaric, 12 ounces each; seeds of Macedonian parsley, 6 ounces; of anise, fennel, cress, seseli, thlaspi, amomum, sandwort, 4 ounces each; of carrot, 2 ounces; *opium*, 24 ounces; opobalsamum, 12 ounces; myrrh, olibanum, turpentine, 6 ounces each; storax, gum arabic, sagapenum, 4 ounces each; asphaltum, opoponax, galbanum, 2 ounces each; juice of acacia and of hypocist, 4 ounces each; castor, 2 ounces; Lemnian bole, calcined vitriol, 4 ounces each; trochiscs of squill, 48 ounces; of vipers, of sweet flag, 24 ounces each.

"Triturate the balsams, resins and gums in a sufficient quantity of wine to form a thin paste, and incorporate the whole with 960 ounces of honey."

Philonium was another famous antidote, invented by Philon of Tarsus, who is supposed to have lived in the early part of the first century of the present era. It is conjectured from an obscure passage in Pliny that this antidote was prescribed against an epidemic of colic or dysentery which occurred in Rome in Philon's time. Philonium was the original of the confection of opium which remained in the English pharmacopeias until 1867. In the Pharmacopei Londinensis of 1746, the ingredients of philonium are given as follows: white pepper, ginger, caraway seeds; strained opium, and syrup of poppies, the proportion of opium being 1 grain in 36 grains of the confection.

Diascordium, the last of the four officinal capitals, was a medicinal compilation by Hieronymus Frascatorius, a famous physician and poet of Vernon in the early part of the sixteenth century, and is given in his book "De Contagio et Morbis Contagiosis." It was originally devised as a preventive of the plague. In the eighteenth century it became a popular household opiate and was frequently given to children for soothing purposes. The original formula, which was adopted in the first London Pharmacopeia in its integrity, mentioned among its principal ingredients cinnamon, cassia wood, scordium, dittany, galbanum, storax, gum arabic, *opium*, sorrel, gentian, Armenian bole, Lemnian earth, pepper, ginger, and honey. Later some of the ingredients were dropped, and the Edinburgh Pharmacopeia made it more astringent by adding catechu and kino. The mangled remains of this famous panacea are represented by the British and U. S. P. Pulvis Catechu Compositus, and Pulvis Kino Compositus.

LATER USES OF OPIUM.

The compound powders of catechu and kino just mentioned are not the only relics of ancient opium compounds remaining in the British and our own pharmacopeias. The commonest pharmaceutic preparations of opium still in use are of antique extraction, and it may be of interest to devote a few words to them at this place.

Our tincture of opium or laudanum dates from Paracelsus (1490-1541). Paracelsus probably applied the name "laudanum" to several medicines, all of which contained opium. This one historian describes a *pill mass* which he designated as laudanum of Paracelsus, and which consisted of one fourth of its weight opium, to which were added henbane juice, mummy, salts of pearls and corals, bone of the heart of a stag, bezoar stone, amber, musk, and essential oils.

Another laudanum, known as anodynum specificum of Paracelsus, was obtained by digesting opium, with orange and lemon juice, frog's sperm water, cinnamon, cloves, ambergris, and saffron. So much for the more ancient laudanum. The laudanum of the early London pharmacopeias was a pill mass, made of a mixture of opium, wine, saffron, castorum, diambrae, ambergris, musk, and oil of nutmeg. The principal liquid preparation of opium used in England a little later was the so-called Sydenham's laudanum. The formula was given by Sydenham in his work on dysentery in 1669-1672, and called for the following ingredients: strained opium, saffron, cinnamon, clover, and canary wine. About the same time, that is, at the end of the seventeenth century, another preparation known as Rousseau's laudanum was much in vogue on the Continent. This differed from the other laudanum in being a fermented compound, and was named after a Capuchin monk by the name of Rousseau. This holy man was sent from Rome to Paris to learn medicine preparatory to mission work in Asia, but became enamored with the subject and settled in Paris to practice the art of healing. He became a favorite with Colbert, the minister of Louis XIV; rooms and laboratory were provided for him in the Louvre, and Louis ordered the Faculty of Medicine to give him a degree.

The name "laudanum," attributed to Paracelsus, is supposed to be derived from the Latin "*laudandum*," "something to be praised." According to some philologists it is related to gum labdanum or ladanum, from which a stomachic cordial was prepared in the middle ages. Others regard it as an abbreviation of the two words *laudatum opium*. Still others endeavor to find in it a corruption of the word *anodynum* with the article prefix, that is, *l'anodynum*, or *the* anodyne, and some latter-day punsters humorously refer to it in bad Latin *Lauda non!* "do not praise," which conveys more truth than poetry.

In the early part of the eighteenth century another celebrated opiate was the so-called "black-drop." Its inventor was one Edward Runstall of Auckland, and it was also known as Lancaster or Quaker's black drop. A formula for its preparation was as follows: Opium, ½ pound; verjuice, 4 pints; nutmegs, 1½ ounces; saffron, ½ ounce. Boil, add two spoonfuls of yeast, and set in a warm place for six to eight weeks; then decant, filter, and put in bottles. This preparation was three times as strong as laudanum, and is the forebear of the English Acetum Opii.

Our other familiar friend and popular household anodyne, paregoric, originated with the elixir asthmaticum of Le Mort, professor of chemistry at the University of Leyden from 1702 to 1718. A modification of Le Mort's formula given in the London Pharmacopeia of 1721 was as follows: honey and licorice root, of each, 4 ounces; flowers of benjamin and opium, of each, 1 drachm; camphor, 2 scruples; oil of aniseed, ½ drachm; salt of tartar, 1 ounce; spirit of wine, 2 pounds. In the London Pharmacopeia of 1746, the name of it was changed to Elixir Paregoricum. In that of 1888 the official name became Tinctura Oii Camphorata. This preparation was also known as Tinctura Camphorae Co., and in the German Pharmacopeia as Tincture Opii Benzoica. The word "Paregoric" comes from the Greek παρηγορικός, which means "soothing" or "consoling."

Our official opium pills, or Pilulae Opii, are not a modern product, but are descended from the old English Pilulae Soponis Company, or Pilulae Soponaceae, which in their turn are an adaptation of the long famous nostrum known as Matthew's Pills or Starkey's Pills. Starkey was a physician who invented them, and Matthew was a vender who sold them. The pills consisted of opium, soap of tartar, and a number of other trivial ingredients.

No account of the history of our opiates can be said to be complete without a reference to Dover's powder, and its originator, the adventurer and knight errant of English medicine, Thomas Dover. I shall not dwell long on the life of this interesting individual, especially as an account of him by Osler[8] has already been published. Born at Barton on the Heath in Warwickshire in 1660, he studied medicine, and in his youth lived at the house of the famous Thomas Sydenham. Many have probably read of how he later joined a privateering party, and led a life of adventure, roaming around the world; how the ship in which he was sailing rescued Alexander Selkirk, the man who lived alone on an island for over four years and who became the prototype of the famous Robinson Crusoe. When he returned to London and settled down to practice, Dover[8] wrote his "Ancient Physician's Legacy to His Country." In this work, in the chapter on gout, he gives the recipe for his "diaphoretic powder" in the following words:

"Take opium, 1 ounce; saltpeter and tartar vitriolated, each 4 ounces; liquorice, 1 ounce; ipecacuanha, 1 ounce. Put the saltpeter and tartar into a red hot mortar, stirring till they have done flaming. Then powder very fine. After that, slice in your opium; grind to a powder and mix. Dose, from 40 to 60 or 70 grains in a glass of white wine posset, going to bed, covering up warm, and drinking a quart or three pints of the posset while sweating. In two or three hours at furthest the patient will be free from pain."

This will suffice for the commoner opium preparations.

THE ALKALOIDS.

Let us now turn from this region of pharmaceutic romance, superstition and mysticism, to some of the achievements that characterize the pharmacy of the nineteenth century, and which mark the beginning of rational therapeutics.

As is well known, throughout the middle ages it was the great ideal of all chemists, or rather alchemists and pharmacists, to search after essences, or quintessences of things, after the philosopher's stone, the elixir of life, etc., and it is natural to find that of all popular drugs opium should be the one especially tortured to give up its essence. Therefore the various laudanums and extracts of opium, and preparations known as magisteria opii, were products of activity exerted in that direction.

Toward the end of the eighteenth century it was a universal belief that plants could elaborate products of only an acid or neutral nature, and that alkalies were substances of a very different character, related more to the metals and exhibiting metallic properties. It was not until the beginning of the nineteenth century, with the discovery of the alkaloids, that this conception was shattered, and it is significant that the first alkaloid to be discovered was the chief active principle of opium—morphin. The honor of this epoch-making discovery belongs to a German, Friedrich Wilhelm Adam Sertürner. Sertürner was born July 19th, 1783, in Paderborn. He became an apothecary and chemist at Einbeck in Hanover, Germany, where he did his most important work, and moved later to Hameln, where he died, February 20th, 1841.

Sertürner began his investigations of opium in 1803, and published the first report of his studies in 1805, when he announced his discovery in opium of an acid, *Opium-Saüre*, which he later named "meconic acid," and which he explained was combined with an alkaline base which he called morphium. In a second communication, in 1816, he gave a detailed account of his work, and described the chemical as well as the pharmacologic properties of morphin, which he tested out on himself, and came near losing his life.

"I flatter myself," he wrote, "that chemists and physicians will find that my observations have explained to a considerable extent the constitution of opium, and that I have enriched chemistry with a new acid (meconic) and with a new alkaline base (morphium), a remarkable substance which shows much analogy with ammonia." Sertürner's discovery excited so much interest, and its importance was regarded as so great, that in 1831 the Institute of France awarded to him a prize of 2,000 francs "for having opened the way to important medical discoveries."

Next in importance to morphin in point of quantity, the opium alkaloid narcotin was discovered really before morphin, in 1803, by the French pharmacist Derosne, who obtained crystals of what proved to be narcotin while diluting a sirupy aqueous extract of opium. These crystals became known as *sel d'opium* of Derosne. The basic or alkaloidal character of the body, however, was not established until 1817 by Robiquet, another pioneer in alkaloidal chemistry. The same Robiquet was the discoverer of the next very important opium alkaloid named codein, in 1832. The discoverer of the next opium alkaloid was another illustrious chemist, Joseph Pelletier, whose name is familiar to us from the active principle of male fern, pelletierin. Pelletier was born in Paris in 1788, and died there in 1842. A son of an apothecary, he was from his earliest days engaged in chemical and pharmaceutic studies, and later became a director of the school of pharmacy in Paris. He was the first to isolate a large number of alkaloids. In 1832 he discovered the opium alkaloids narcein and oxymorphin, and in 1835, with Thibouméry, another alkaloid, thebain.

[8] Osler, W.: Bull. Johns Hopkins Hosp., 1896, vii, 1.

[8] Dover, Thomas, M.B.: The ancient Physician's Legacy to His Country, London, 1762.

Pelletier was also the discoverer of strychnin, and together with Caventou, of brucin, quinin, and chinchonin, together with Magendie of the at present interesting emetin, together with Corriol of aricin, together with Thibouméry of pseudomorphin, together with Couerbe of picrotoxin, and together with Pelleton of berberin. Since his time opium has become a nidus for a large number of alkaloids, and promises to yield a few more. Up to the present, according to Winterstein and Trier,[1] opium has yielded besides protein bodies, sugar, gum, resin, salts, and organic acids, twenty-two different alkaloids of which the following is a list: morphin by Sertürner in 1804; narcotin by Robriquet in 1817; codein by Robriquet and narcein by Pelletier in 1832; thebain and pseudomorphin by Pelletier and Thibouméry in 1835; papaverin by Merck in 1848; cryptopin in 1857; gnoscopin in 1878 and xanthalin in 1893 by T. and H. Smith; codamin, laudanin, meconidin, and lanthopin by Hesse in 1870; laudanosin and hydrocotarnin in 1871, and protopin in 1872, also by the same investigator; oxynarcotin, by Beckett and Wright in 1875; tritopin by Kander in 1890; laudanidin by Hesse in 1894; and last, pseudopapaverin and papaveramin by the same man in 1903.

Besides the primary opium alkaloids, a large number of derivatives of them have been made, which we need not enumerate here. Let me but mention apomorphin, apocodein, heroin, dionin, and peronin.

All these chemical individuals have been analyzed, their empiric formulas established, and an attempt, at least in case of some of them, has been more or less successfully made to determine their structure. Along with this chemical work, which forms one of the most brilliant chapters of modern chemistry, a great deal, though by no means complete or sufficient, physiologic and pharmacologic work has been done with them.

Only within the last few years, the work of Straub, Faust, Bürgi, Sahli, and others has marked a still further step in our knowledge of their therapeutic properties. These authors have shown that not only have the various opium alkaloids individually definite pharmacologic actions, but that also still other effects can be produced by combining them with each other.

Thus, if we trace the history of opium from its earliest beginnings to the brilliant researches of recent years, if we but compare the analytic and synthetic, chemical, physiologic, and pharmacologic studies of the same old drug with the fantastic and puerile effusions on the subject of our medical predecessors, we cannot help being impressed with the long strides forward which medicine has made; yet, on the other hand, our very recent studies on opium and its alkaloids serve but to emphasize the more our meager knowledge of the subject and the still greater task before us.

Coal Substitutes*

Use of Chalk Fuel and Peat Proposed in England

If coal remain at a prohibitive price it cannot be expected that, after their present contracts have run out, the suppliers of gas and electricity will continue to let us have these essentials at the old price. Already, in certain industries, it is being found cheaper to use some other source of power than coal, and this is a tendency that will increase as long as the price of coal is rising and that of gas and electricity remains stationary. It is a tendency, however, deserving of every encouragement, for the consumption of coal in small quantities is often a wasteful proceeding, and we ought as a nation to do everything we can to economize fuel, so as to have no shortage when the time of great industrial expansion arrives after the war.

It was stated some months ago—before the war—that "the internal combustion engine is the power agent of the future, and it will be a problem of no mean dimensions to provide the very large supplies of fuel which we must have if we are to hold our own in the world's markets." The reference was largely to liquid fuels, but we have to consider also the internal combustion engine which derives its energy not only from petroleum, its allied products, or even from alcohol, but from producer-gas. In this latter case anthracite has been a necessity heretofore.

Some recent experiments would seem to suggest that there may be available in this country suitable substitutes not only for anthracite in gas-producers, but also for coal generally, even for domestic purposes.

One of these substitutes consists of a mixture of chalk, rough small refuse coal, and solidified tar, in the proportions, respectively, of about 60, 30, and 10 per cent, the mixture being compressed into ovoids or pieces about the size of a large plum. This chalk-fuel, as it may be termed, burns freely, when once combustion is started, in an open grate or under a boiler, and is quite smokeless.

The idea of using crude chalk in the grate alongside with coal is not a new one, and it is often claimed that economy of coal results in this way, which is quite possible seeing that chemical action proceeds when chalk is heated, this chalk giving up some of its oxygen to form carbon-monoxide, and lime being left behind as ash. But the addition of the above-mentioned carbonaceous substances to the chalk naturally increases both its heating value and freedom of combustion, and the resulting chalk-fuel is expected to be a useful fuel in the future, especially as destructor refuse can be worked in as one of the materials composing the compressed ovoid. This is a valuable feature, as many towns spend as much as 10s. per ton to get rid of their refuse.

The materials required are so cheap that it would seem to be possible to produce this fuel at about half the normal price of coal, at any rate on the South Coast, where chalk is plentiful and coal expensive.

From an engineering point of view, the experiments in power production that have been made on a gas-producer plant are instructive. This particular plant ran two gas engines of 90 brake horse-power each, and supplied gas (equivalent to 10 horse-power) to lacquering ovens. Using bituminous coal, the fuel consumption was 23 hundredweight per twelve hour day, as compared with 17 hundredweight of chalk-fuel for the same period. As might be imagined, the gas from the latter was much cleaner than that produced from anthracite or coke. The lower fuel consumption meant that stoking was not so frequent, and consequently a saving of labor could be effected; further, there was no clinkering.

An interesting point in the running of the engines was that much more air could be admitted to the mixing chamber than was the case with ordinary gas; in fact, the air-valve could be worked fully open. This rather bears out the assumption that an unusual amount of carbon monoxide gas was formed (from the disintegrating chalk, which afterward falls to the bottom of the producer as lime), and this would, of course, need an extra amount of air for efficient combustion, and would explain why less fuel was required to give the same amount of power. The flames arising from the gas when burnt in the lacquering ovens were also very hot, as they would be from a gas rich in carbon monoxide. The latter gas, it was shown by analysis, was present to the extent of 18 per cent, other constituents being carbon dioxide, 10 per cent; hydrogen, 7 per cent; marsh gas, 4 per cent; and nitrogen, 61 per cent.

The fuel itself, when analyzed, was found to consist of fixed carbon, 28.45 per cent; volatile matter (including water), 26.95 per cent; and ash, 44.6 per cent. It should be possible to use it in locomotives, and, as there is also the prospect of the use of gas-producers on shipboard for driving internal combustion engines, we may yet see the chalk cliffs of old England becoming a diminishing quantity in order that England's ships may put out to sea.

A second substitute for coal in this country is peat, of which there are vast quantities in Ireland, Wales, Scotland, and also in many parts of England.

A great amount of work has been done in the direction of employing peat as a fuel, especially in Canada and the United States, where peat fuel is in regular use in place of coal, and it has been shown that, besides being useful for domestic purposes, peat can be used under boilers or in gas-producers. Peat dust formed into briquettes with 5 per cent of coal dust has been successfully used in locomotives drawing trains weighing from 218 to 260 tons, the consumption of peat fuel being just twice as great as was the case when coal alone was used.

That the use of peat for driving gas engines is not now a mere experiment is clear from the success of the recently established Weismoor electric generating station in East Friesland, where the total supply per annum of energy for lighting and power is now almost 10,000,000 kilowatt-hours, all derived from peat-consuming gas-producers.

A smaller but similar British plant has been found to give very much more satisfactory results with peat than with coal after the separation of tar from the gas had been effected by means of an ample water spray for cooling and washing the gases, the tar being thrown out by a centrifugal tar extractor. The plant can be run for three weeks without cleaning, and the saving in cost between running the factory on coal and on peat amounts, when peat is employed, to over £15 per week.

The Canadian Department of Mines has had a series of peat-fuel tests made on a Körting gas engine at the Ottawa Fuel Testing Station, which show that the fuel consumption per brake horse-power hour—including stand-by losses—is for full load, 1.7 pound of peat, or 2.3 pounds of peat containing 25 per cent moisture; for three quarter load the corresponding figures are 2.1 pounds and 2.8 pounds. Assuming that peat can be delivered to the plant at 8s. 6d. per ton, and that the plant be run with a power factor of 75 per cent for 3,000 hours, the fuel costs would be 36s. per brake horse-power year, including stand-by losses.

Peat fuel is expected to have a big future, not only in this country, but in Canada, Russia, and other countries possessing large peat deposits. Russia alone has more peat than all the other countries of the world, and it has been calculated that its average selling price in Russia should be about 9s. 6d. per ton. There would thus appear to be a useful opening for British engineers to develop a new branch of industry—the supply of the necessary gas engines and gas-producers for use with peat fuel.

* *The London Daily Telegraph.*

[1] Winterstein and Trier: Die Alkoloide, Berlin, 1910.

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